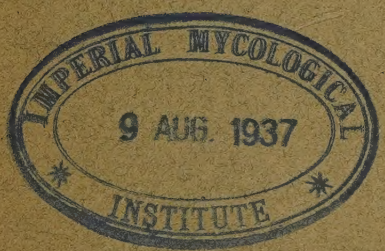
VOL. 8 FIRST QUARTER, 1937 No. 1

The Philippine Journal of Agriculture

PUBLISHED QUARTERLY BY
THE DEPARTMENT OF AGRICULTURE AND COMMERCE



MANILA
BUREAU OF PRINTING
1937

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DEPARTMENT OF AGRICULTURE AND COMMERCE

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THE PHILIPPINE JOURNAL OF AGRICULTURE

Published quarterly by the Bureau of Plant Industry, Department of Agriculture and Commerce
Entered at the Post Office at Manila, Philippines, as second-class matter

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A STUDY OF DIFFERENT SPECIES OF AGAVE [1]

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Maguey has been produced on a commercial scale in the Philippines since the early part of the twentieth century but other allied species of Agave have barely come into prominence. The defunct Bureau of Agriculture introduced sisal in 1905 from Hawaii and considerable attention was taken in its cultivation but up to the present only patches of ground planted to sisal may be found here and there. Henequen had been brought here from Mexico but its cultivation is still left on an experimental scale. Like maguey these species of Agave have been found suitable under our soil and climatic conditions. With improved preparation of the fiber by the use of modern machinery and a better market price for the product, this crop will eventually be widely grown in our principal fiber-growing provinces. There is no doubt that during typhoons, droughts and other calamities causing a decrease in our cereal production, these species of Agave will be found good as emergency crop.

The Bureau of Plant Industry in an attempt to popularize these species of Agave and revive the interest on the growing of these crops conducted experiments on the different species which are the subject of the present work. This paper is an endeavor to classify the five species of Agave and to determine their comparative merits under field conditions at the Lamao Experiment Station, Limay, Bataan.

[1] Conducted at the Lamao Experiment Station, Limay, Bataan.

DESCRIPTION OF DIFFERENT VARIETIES

Maguey, *Agave cantala* Roxb.—Introduced into the Philippines from Mexico. Commercially grown in Java and British India. May be planted either by suckers or bulbils. When planted by suckers the first crop may be obtained in three years and from bulbils about a year later. It does not develop a real trunk. Produces from 156 to 185 leaves per plant. Leaves grayish-green, long, wavy, with terminal and marginal spines and measuring on the average 170.24 centimeters long and 6.58 centimeters wide. Fiber white, fine, about 113 centimeters long and may be extracted by retting and stripping. Largely used for rope making and for other tying purposes. The Philippine product in the market is known as "Manila maguey," "Manila Aloe," and "Philippine maguey."

Sisal, *Agave sisalana* Per.—Introduced into the Philippines by the Bureau of Plant Industry in 1905 from Hawaii. Widely grown in Java, East Africa, India, and Bahamas. When planted by bulbils the first crop may be obtained in about four years' time. Like maguey, sisal does not develop a real trunk. Produces from 148 to 178 leaves per plant. Leaves green, wide, rigid and with terminal spines. Marginal spines partly or totally absent. Leaves measuring on the average 131.26 centimeters long and 8.57 centimeters wide. Produces polls from six to eight years. Fiber white, coarser and stronger than maguey. In commerce the fiber is known as "sisal" preceded by the name of the country producing it.

Henequen, Agave fourcroydes Lem.—Introduced from Puerto Rico. When planted by bulbils the first crop may be obtained in about four years' time. Producing from 112 to 124 leaves per plant. Leaves green, long, rigid, with terminal and marginal spines and measuring on the average 103.99 centimeters long and 8.34 centimeters wide. Fiber of a dull white color, quite long measuring about 110 centimeters. In the market the fiber is known as "sisal" or "Mexican sisal." Fibers largely used for binder twine.

Zapupe, *Agave Zapupe*.—Introduced from Mexico in 1905. Grown first at La Carlota, Occidental Negros, in 1912, where the Lamao materials were obtained. Very much like Henequen in habit of growth. Produces from 73 to 106 leaves per plant. Leaves green, shorter than Henequen, rigid, with terminal and marginal spines and measuring on the average 96.77 centimeters

long and 7.14 centimeters wide. Fiber white, quite short, measuring only about 83 centimeters long.

Agave sp.—Introduced probably from Puerto Rico. Good for ornamentals producing small and pale green leaves closely set at the trunk. The leaves on the average are 46.28 centimeters long and 6.26 centimeters wide and provided with marginal and terminal spines. This species of Agave produces the shortest and whitest fiber. The fiber is rather coarse measuring about 72 centimeters long.

EXPERIMENTS AND RESULTS

Variety test.—On a fairly uniform land a variety test of the above species of Agave was begun on June 12, 1923, using maguey as check. One hundred seventy-two suckers from each species were planted excepting in the case of Agave zapupe and Henequen of which only 96 and 28 suckers were planted respectively. The distance of planting was 1.5 meters apart each way. Both ends of the field were planted with maguey as checks. The lay-out of the experiment plots may be diagrammatically represented as follows:

Maguey Check 1	Sisal	Agave sp.	Maguey (Test)	Henequen	Agave zapupe	Maguey Check 2

All plots were weeded twice every year. The first harvest was made in 1928 and yearly thereafter. Only mature leaves from five individual plants of each species were harvested to determine the yield. The fiber was extracted by retting the leaves in water for 15 days and then beating them until all the pulps were removed. Then the fiber was sun-dried and weighed.

The following table shows the data obtained from 1928 to 1931 inclusive:

TABLE 1.—*Showing the annual and average yields*

Variety name	1928	1929	1930	1931	Yearly average
	Kilos	*Kilos*	*Kilos*	*Kilos*	*Kilos*
Sisal	4,430.22	1,897.588	4,932.84	7,521.47	4,695.454
Agave sp.	1,235.55	244.42	2,266.44	4,215.134	1,740.384
Maguey	4,106.66	1,879.812	6,443.80	6,619.338	4,762.400
Henequen	1,068.44	1,248.764	4,915.064	4,335.122	2,891.840
Agave zapupe	2,615.60	697.708	5,577.220	3,472.986	3.090.878

Stripping and retting test.—It was the object of this experiment to determine the comparative percentage of fiber of the above species of Agave by stripping and retting. A known quantity of leaves from the above species of Agave was weighed, knife stripped and subsequently dried in the sun. The weight of the sun-dried fiber was then taken and from this the percentage of fiber was obtained.

In the case of the latter, a known quantity of the leaves was harvested and weighed. Then the leaves were slit into strips, bundled and soaked separately in salt, semi-salt, and fresh water. At the end of 15 days the bundles were removed and beaten until all the pulps were taken away. Then the fiber was washed and dried in the sun and from the weight of the sun-dried fiber the percentage of fiber was calculated. The following table shows the results obtained:

TABLE 2.—*Showing the percentage of fiber by stripping and retting*

Variety name	Knife stripped fiber	Salt-water retted fiber	Semi-salt water retted fiber	Fresh water retted fiber	Average
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Maguey	1.50	2.84	4.11	11.74	6.32
Sisal	2.46	1.56	1.93	3.43	2.30
Henequen	1.80	2.12	3.70	1.92	2.58
Agave zapupe	3.00	7.50	2.40	6.00	5.30
Agave sp.	2.00	1.25	6.40	2.66	3.43

DISCUSSION

Table 1 shows that maguey (Agave cantala) from the average of four years' test yielded 4,762.40 kilos of fiber, the highest among the five species of Agave under study. Sisal (Agave sisalana) yielded 4,695.454 kilos, the second highest yielding in the group. Agave zapupe was the third ranking variety giving an average yield of 3,090.878 kilos of fiber per hectare. Henequen (Agave fourcroydes) and Agave sp. yielded 2,891.84 and 1,740.384 kilos of fiber, the fourth and lowest yielding varieties.

As may be seen from the above results, the individual yield varies from year to year. In the case of maguey the yearly yield for a period of four years were: 1928—4,106.66 kilos; 1929—1,879.812 kilos; 1930—6,443.8 kilos; and 1931—6,619.338 kilos. This is principally due to varieties and secondarily to climate.

The annual rainfalls during the period of four years were as follows: 1927, 119.71 inches; 1928, 106.25 inches; 1929, 112.19 inches, and 1930, 108.29 inches. The comparatively low yield in 1929 may be due to a low precipitation in 1928 (106.25 inches) which probably affected the 1929 crop. Again the yield in 1928 was comparatively high which must have been due to the high rainfall in 1927 (119.71 inches). In this connection, it may be added that yield determination was done in all cases from January to February of each year so that the crop for that year was affected by the rainfall of the year just preceding.

From the results of the stripping and retting tests shown in Table 2 it is very evident that excepting the case of sisal, retting gave a decided advantage over stripping as far as the percentage of fiber obtained is concerned. In the case of maguey the average of retted gave 6.32 per cent fiber as aginst 1.50 per cent of the knife-stripped. Also, in the case of Henequen, the advantages of Agave zapupe and Agave sp. go with the retted, the percentage of fiber obtained being more than the knife stripped.

SUMMARY

1. Five different species of Agave, namely, Agave cantala, A. sisalana, A. fourcroydes, A. zapupe and Agave sp. have been described in this paper.

Maguey, *Agave cantala,* produces a long fine white fiber known in commerce as "Manila maguey," "Manila Aloe," and "Philippine maguey."

Sisal, *Agave sisalana,* produces a coarse white fiber known in the market as "sisal."

Henequen, *Agave fourcroydes,* otherwise known as "Mexican sisal" produces a coarse white fiber like sisal but stronger.

Zapupe, *Agave zapupe,* resembles Henequen in habit of growth but is generally smaller than the latter. It produces a white fiber less than a meter long.

Agave sp. is an unidentified species of Agave which produces the whitest but, the shortest fiber.

2. The yield of the above species of Agave was influenced by the annual rainfall—a factor which caused a distinct variation in the increased yield of the following crop.

3. Retting gave a decided advantage over knife stripping in that more fiber was obtained in the former method. Maguey,

zapupe and Agave sp. gave the highest average percentage of fiber in both methods.

4. On the strength of the evidence presented in this paper it may be concluded that the two species of Agave that are decidedly the best are maguey and sisal.

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EFFECTS OF VARIATION IN MOISTURE CONTENT OF SANDY LOAM SOIL IN POTS UPON WRAPPER-LEAF TOBACCO

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Of the Tobacco Research Section, Bureau of Plant Industry

THREE TEXT FIGURES

The results of investigations reported by Montgomery and Kisselbach (1912), Briggs and Shantz (1913–1914), Kiesselbach (1916), Miller (1916–1923), and Thom and Holtz (1917) show no relationship between the ability of a plant to withstand drought and its water requirement. On the other hand an increase of the water content of the soil affects the quality of produce obtained from the crop. Tatcher (1913) showed that there was a decrease in protein content of wheat in eastern Washington with an increase in rainfall. Greaves and Carter (1923) also observed a decrease in the nitrogen content of wheat, oats, and barley as the irrigation water used in their growth was increased. Further in 1924, Neidig and Snyder noted that under field conditions as high moisture content properly distributed during the growing season in an average soil produces a high yielding wheat with a low protein content. So far no experiment of this kind has been tried on tobacco.

The extent to which the growth of tobacco plants and the quality of the leaves produced as affected by soil-moisture had been the subject of study of the Ilagan Tobacco Experiment Station. The plants were grown in soil contained in petroleum cans. In the absence of a suitable shelter-house or greenhouse to protect the plants from rain, the cultures were placed under the side-shade of the warehouse building. Under this condition, the plants were grown under partial shade. The results obtained were encouraging but the study was discontinued due to lack of necessary shelter. However, it was again taken up at the Central Experiment Station, Manila, immediately after the greenhouse of the Tobacco Research Section was built.

The results secured under controlled conditions confirmed in general the trend of data secured at Ilagan. Hence, only the

findings gathered at the Central Experiment Station are here reported. The former records are kept on file in the Tobacco Research Section for reference.

The tobacco plants were grown in big bondex cans capable of holding 55 kilograms of ordinary air-dry-sandy loam soil and placed in the greenhouse. The experiment was conducted in duplicate cultures and repeated twice at different seasons of 1935 and 1936.

MATERIALS AND METHOD

Preparation of seedling.—Seeds of Ilagan Sumatra variety were sown in soil contained in seed boxes. When the seedlings were 28 days old they were pricked to another seed-bed previously prepared and allowed to remain there until they were 60 days old. At the time of transplanting the seedlings to the Bondex cans, they averaged 10 cm. high with 5 well developed leaves and had an average total leaf product of 254 sq. cm.

Soil used.—Enough sandy loam soil to fill 20 bondex cans 34 cm. in diameter and 50 cm. in depth were collected at the Central Experiment Station field. The soil was spread to dry in the greenhouse until its constant air-dry weight was obtained. The soil was thoroughly mixed previous to filling the containers with it. Each can contained 55 kilograms of air-dry soil.

Preparation of various constant soil-moisture.—The average of three trials showed that 55 kilograms of air-dry-sandy loam-soil when placed in a Bondex can required 19 liters of water to saturate it. This state of wetness was considered as 100 per cent saturation. This volume of water (19 liters) was used as the basis in the calculation for the different soil saturations as 90, 80, 70, 60, 50, 40, 30, 20 and 10 per cent. Thus, in the 90 per cent saturation, the amount of water added to the soil was 17.1 liters (19 liters $\times$ .90 $=$ 17.1 liters). The others were prepared similarly. In the 10, 20, 30, 40, 50, 60 and 70 per cent saturations the water added to the soil to make the necessary saturation was not poured directly on the soil in the bondex can. The soil was removed from the container and spread on a cement floor. Then the amount of water required to make the desired saturation was sprayed and mixed thoroughly with the soil after which the moistened soil was returned to the can. This operation was necessary especially in the 10 and 20 per cent saturations because the amount of water to be added was too little, and if poured into the can

directly only the upper layer of the soil contained in the can could be made wet while the lower ones would remain dry. Consequently, the degree of wetness of the medium would not be homogenous.

Method of watering the plants.—One of the greatest difficulties experienced in growing plants in large containers is to replace evenly throughout the soil the water that has been removed by the plant. To remedy this situation a modification of the method of Miller (1916–1923) was devised as shown in Fig. 1. By means of a soil tube three cylindrical masses of soil 5 cm. in diameter and 25 cm. in depth were removed from the upper portion of the soil. These cavities were then filled with fine gravels and coarse sand. When the plants were watered, the water was poured into these cavities and allowed to diffuse throughout the soil.

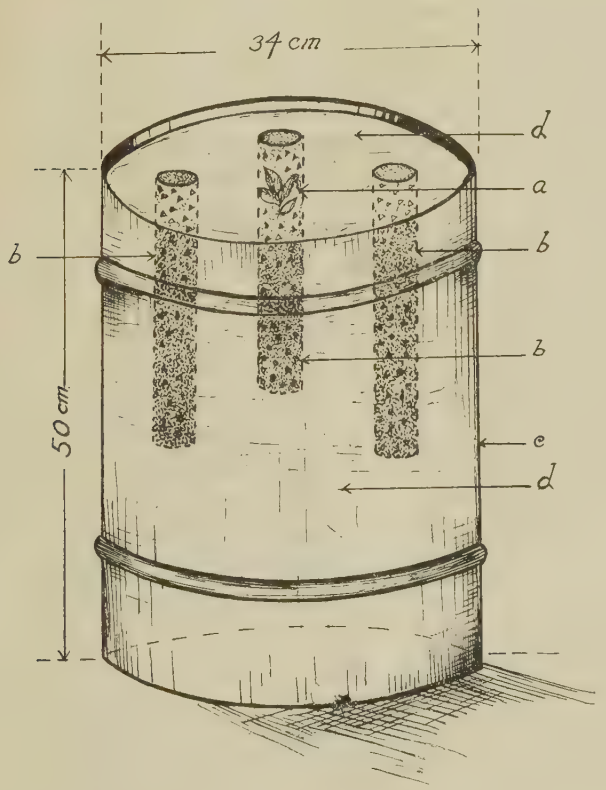

FIG. 1. Diagram showing method used in growing tobacco plant in soil contained in large containers. *a*, plant. *b*. sand and gravel. *c*, metal container. *d*, soil.

The plants were placed in rows in the greenhouse and weighed every other day. The lost weight through soil surface evaporation and transpiration was regained by adding enough water to bring back the weight of the culture to its original weight. Hence, the soil-moisture in each can was practically kept constant throughout the life of the tobacco plant.

Growth measurement.—At frequent intervals from the date of transplanting to the time of first priming on November 21, the length of each leaf was obtained from the axil of the leaf to the tip of the lamina, and the width was taken at the widest part of the leaf. Every time leaf measurements were made, dried or yellow leaves and the young leaves shorter than 2 cm. long were not included. Determinations of actual leaf areas were not made, but the leaf product was employed. This is an index obtained by multiplying the length of the leaf by its width; it represents approximately the true leaf area. The leaf products were used to indicate the relative vigor of the different set of cultures at different stages of the development of the tobacco plant. The breadth index was obtained by dividing the width of the leaf by its length and the quotient multiplied by 100. The total height of all the plants was taken on December 10. The height of the plants that flowered was measured from the ground to the tip of the inflorescence and the height of those that did not flower was observed from the ground to the axil of the youngest visible leaf.

Determination of burning quality.—After the leaves had been cured, strips one centimeter wide were cut crosswise at the middle of the leaf from both sides of the lamina. The strips were placed in separate envelopes and dried in the oven at 60° C. for a period of one week. Later they were transfered to a desiccator to cool. With the use of a burning alcohol lamp, the tobacco strips were ignited and the length of time the strips kept glowing was recorded. There were one hundred determinations taken from each set of plants but only the average of these figures is reported here.

Samples for chemical analysis.—Sufficient and representative leaf samples from each set of plants were taken and submitted to the Agricultural Chemistry Section of the Bureau of Plant Industry for analysis. Following the official method of pro-

cedure the following were determined: ash content, total nitrogen, nicotin, and color of ash.

RESULTS

The average growth measurements of the plants (leaf products) in two separate trials are given in Tables 1 and 2 and shown graphically in Figure 2. The harvest data are also tabulated, Tables 3 and 4, and graphed as shown in Figure 3. Table 5 shows the chemical analysis and quality of leaves harvested from plants grown in various constant soil-moisture.

For the sake of clarity the results of this study are discussed under three headings. The effect of various constant soil moisture upon the rate of growth of the plant is given first, then its effect upon the final make-up of the plant, and finally, its effect upon the chemical content and quality of the crop produced.

EFFECT OF SOIL-MOISTURE UPON THE RATE OF GROWTH

An examination of Tables 1 and 2 and particularly of the graphs in Figure 2 shows that the amount of moisture in the soil has a profound effect upon the rate of growth of tobacco plants. Insufficient amount of soil-moisture as well as too much water in the medium both retarded the rate of growth of the plants. Very rapid growth was noted under greenhouse conditions when there was ample moisture and air supply in the medium. This state of condition was attained when the per cent saturation of the soil ranged between 60 and 70.

If the plant which had the biggest leaf product observed on September 12 be given a value of 100, the relative value of the rate of growth of the different cultures beginning from the lowest per cent saturation to the highest would be: 49, 79, 93, 96, 99, *100*, 99, 91, 80 and 63. The plants in the 60 per cent saturation grew the fastest. The leaf product increased from 254 sq. cm. to 330 during a period of one week from date of transplanting. Those plants grown in the 50 and 70 per cent saturations were close second (Table 1). At 10 and 100 per cent saturations the lower leaves of the plants died which resulted to a reduction in leaf area. The leaf area of green leaves was reduced to 36 per cent in the former and to 18 in the latter.

Another growth measurement of the plants was taken six days later (September 18). When graphed (Fig. 2) the trend

TABLE 1.—*Results of first trial showing average total leaf products in relative values of tobacco plants grown in soil of various constant soil-moisture observed at different periods of growth development*

Per cent saturation	Period of observation					
	September 12	September 18	September 25	October 4	November 8	November 21 [a]
100	68	40	24	18	15	13
90	80	79	62	52	44	43
80	91	91	89	83	71	[c] 70
70	99 (330 sq. cm.)	99 (767 sq. cm.)	98 (1,908 sq. cm.)	97 (4,089 sq. cm.)	(6,893 sq. cm.) 100	(7,156 sq. cm.) [b] 100
60	100	100	100	100	99	[b] 99
50	99	93	91	89	85	[c] 84
40	96	85	82	79	68	66
30	93	76	69	64	54	52
20	79	62	50	47	38	35
10	49	37	31	29	26	25

[a] After the leaves were measured on November 21, the first four lower leaves from each plant were harvested.
[b] On November 19, flower buds appeared.
[c] On November 21, flowers buds appeared.

TABLE 2.—*Results of second trial showing leaf products in relative values of tobacco plants grown in soil of various constant soil-moisture observed at different periods of growth development*

Per cent saturation	Period of observation					
	December 26	January 3	January 10	January 26	May 6	March 19 [a]
100	76	63	35	25	21	20
90	85	79	70	50	44	41
80	93	85	80	75	72	[c] 69
70	99 (350 sq. cm.)	98 (1,817 sq. cm.)	97 (2,047 sq. cm.)	98 (5,493 sq. cm.)	(8,509 sq. cm.) 100	(9,066 sq. cm.) [b] 100
60	100	100	100	100	99	[b] 99
50	98	98	96	93	90	[c] 90
40	92	90	88	80	72	69
30	84	79	70	62	46	44
20	75	70	60	50	36	34
10	60	50	40	30	25	24

[a] After the leaves were measured on March 19, the first four leaves from each plant were harvested.
[b] On March 10, flower buds appeared.
[c] On March 19, flower buds appeared.

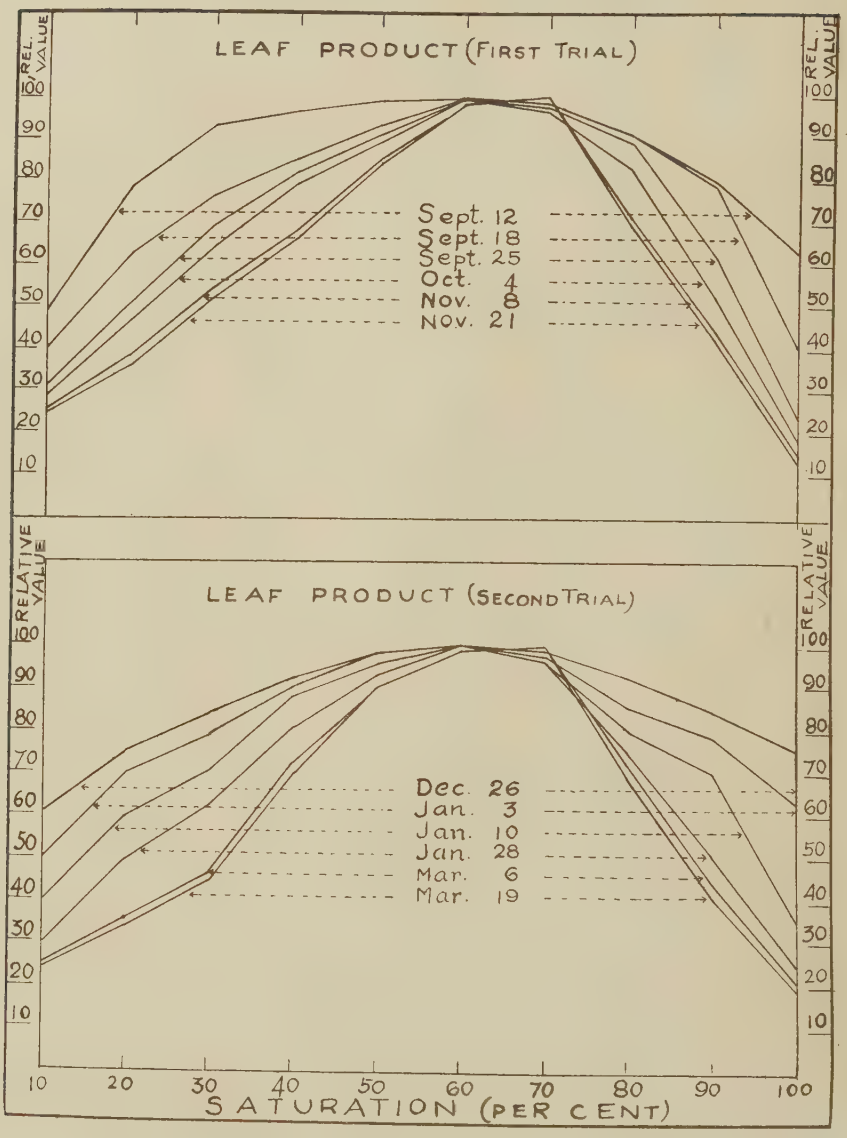

FIG. 2. Graphs showing effect upon the vigor of tobacco plants at different stages of growth development of varying the moisture content of sandy loam soil in pots.

of growth-curve of the plants is the same as the growth-curve observed on September 12. And, similar measurements obtained on September 25 and October 4 showed more markedly the effect of varying the moisture content of the soil upon the rate of growth of the tobacco plants. During this period the

plants in the 60 per cent saturation still maintained the lead in the rate of fast growth. Starting from the lowest to the highest per cent saturation the total growth of the plants on October 4 expressed relatively was: 29, 47, 64, 79, 89, 100, 97, 83, 52 and 18 (Fig. 2). It is to be noted that the plants in the 100 per cent saturation were now poorer than those in 10. The former had a relative value of 18 and the latter 29. It is apparent that an insufficient amount of aëration in the medium (100 per cent saturation) was more detrimental to the growth of the tobacco plant than a deficiency of soil-moisture as low as 10 per cent saturation. In fact, on November 21, the duplicate culture in the 100 per cent saturation died and the one living had its leaves chlorotic and the lower ones were dried. The poor condition of the plants in this saturation (100) is due to the lack of sufficient supply of oxygen. This contention is supported by Maximov who states:

> On too compact or submerged soils, ... plants developed poorly, or perish . . . . It is not the excess of water itself that is injurious to the plant, ... it is rather the lack of oxygen resulting from submersion that is harmful . . . . Lack of aëration may lead to other consequences having an indirect effect of the root system . . . . The various bacterial processes of the soil, for instance, may be replaced by anaerobic fermentation . . . . Poisonous products of anaerobic decay may accumulate in the soil . . . . All these substances poison the roots of plants and check water absorption.

In the light of Maxinov's explanation aëration especially for plants like tobacco should not be overlooked, nor arid soil should be preferred. For in medium with insufficient soil-moisture supply, the root hairs compete for water with the surrounding soil particles. The results of this study (Tables 3 and 4) show that beginning from 10 to 40 per cent saturations, inclusive, the plants under greenhouse conditions were always at a constant demand for more water as shown by the fact that the plants wilted during periods when conditions were favorable for rapid transpiration. The growths of these plants were also stunted. This interrupted rate of water absorption was detrimental to the normal development of the plants. In the words of Maximov he states:

> The greatest increase in volume of cell occurs . . . . only when water has an un-interrupted and unhindered access to the growing cells. With deficiency of water or an accumulation in the soil of substances inhibiting water supply the stage of elongation terminates too early and differentiation begins before the cells have reached their full size. The result will be a plant with smaller cells and shorter growth.

TABLE 3.—*Results of first trial showing average harvest data of tobacco plants grown in soil of various constant soil-moisture*

Per cent saturation	Average total height	Average number of leaves per plant	Average measurement of 5 largest leaves from 1 plant			Average yield per plant (relative value)	Appearance of plant at priming period
			Length	Width	Breadth index		
	cm.		*cm.*	*cm.*	*cm.*		
100	37.5	8	16.8	9.0	54	13	Plant, chlorotic (pale yellow green). Growth stunted. Old leaves, dried. Duplicate plant, dead. No flower.
90	65.0	15	22.0	12.1	55	38	Plant, pale-yellow-green. Growth stunted. One plant with mosaic symptom. No flower.
80	112.3	28	28.1	15.1	54	64	Plant, light-green. Growth fairly normal. One plant with mosaic symptom. No flower.
						(31 gm.)	
70	159.0	30	32.3	17.8	55	100	Plant, well developed with long and broad light-green leaves. With flower.
60	153.1	30	32.4	17.8	55	100	Resembling plants in 70. With flower.
50	133.1	28	30.0	16.2	54	83	Plant, grass-green. Older leaves, dried at tips. Growth not vigorous. No flower.
40	124.5	23	24.9	13.2	53	63	Plant, grass-green. Young leaves wilt at middle of day. Growth, slow. No flower.
30	105.0	18	24.9	13.4	54	54	Plant, grass-green. Young and medium-aged leaves wilt at middle of day. Growth, stunted. No flower.
20	71.8	15	22.9	12.3	54	45	Plant, grass-green. Leaves wilt at middle of day. Growth, stunted. Older leaves, dried. No flower.
10	55.5	10	19.0	10.2	54	24	Plant, grass-green. Leaves wilt as early as 10 o'clock in the morning. Growth, stunted. Older leaves, dried. No flower.

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TABLE 4.—*Results of second trial showing average harvest data of tobacco plants grown in soil of various constant soil-moisture*

Per cent saturation	Average total height	Average number of leaves per plant	Average measurement of 5 largest leaves from 1 plant			Average yield per plant (relative value)	Appearance of plant at priming period
			Length	Width	Breadth index		
	cm.		*cm.*	*cm.*	*cm.*		
100	41.0	10	16.6	8.8	53	15	Plant, chlorotic. Growth stunted. Older leaves dried. No flower.
90	92.1	20	22.2	12.2	55	40	Plant, pale yellow. Growth stunted. Older leaves, dried. No flower.
80	150.0	28	26.9	14.5	54	69 (32 gm.)	Plant, pale green. Growth stunted. No flower.
70	160.0	31	32.1	17.0	53	100	Plant, vigorous. Leaves, green, long, and broad. With flower.
60	158.2	30	31.6	17.4	55	98	Plant, vigorous. Leaves, green, long, and broad. With flower.
50	141.1	25	30.0	16.2	54	85	Plant, vigorous. Leaves, green, long, and broad. With flower.
40	122.0	25	25.3	13.4	53	65	Plant, green. Young leaves wilt at middle of day. Growth slow. No flower.
30	92.3	20	23.9	12.9	54	56	Plant, green. Leaves wilt at middle of day. Growth, slow. No flower.
20	70.1	16	22.5	12.4	55	42	Plant, green. Growth, stunted. Leaves wilt as early as 10 a. m. until 4 00 p. m.
10	62.0	12	17.8	9.4	53	27	Plants, green Growth, stunted. Leaves small and wilt as early as 9.00 a. m.

TABLE 5.—*Chemical content* [a] *and quality of crop obtained from plants grown in soil of various constant soil-moisture*

Per cent saturation	Moisture	Ash		Nitrogen		Nicotine		Duration of glow	Color of ash [b]
		Wet	Dry	Wet	Dry	Wet	Dry		
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Second*	
100	9.39	26.68	29.44	0.47	0.51	(c)	(c)	5.0	Palid quaker drab.
90	8.34	24.04	26.22	0.57	0.62	(c)	(c)	5.0	Do
80	8.50	26.67	29.14	0.11	0.12	(c)	(c)	5.2	Do
70	10.05	30.75	34.18	0.72	0.80	(c)	(c)	6.0	Do
60	9.01	28.27	31.06	1.16	1.27	0.84	0.92	4.8	Gray (pale gull gray).
50	10.95	28.50	32.00	0.98	1.30	2.07	2.32	2.6	Palid mouse gray.
40	10.98	28.72	32.26	1.24	1.39	1.24	1.39	3.0	Do.
30	13.45	32.15	34.14	1.13	1.20	2.22	2.35	2.8	Do.
20	11.13	28.47	32.03	1.38	1.55	1.82	2.04	2.4	Do.
10	12.23	27.97	31.86	1.19	1.35	2.26	2.57	2.5	Pale mouse gray.

[a] Analyzed by the Agricultural Chemistry Section, Bureau of Plant Industry.
[b] Color of ash was compared with Ridgway's Color Standards and Nomenclature.
[c] Nicotine not detected on the amount of sample used.

It is also interesting to note that toward flowering period when the plants were already 57 days old (November 8) from the date of transplanting, the plants in the 70 per cent saturation had overcome and exceeded the growth rate of the plants in the 60 by one per cent. The plants in the 70 per cent saturation took the lead by having the biggest leaf product. This behaviour of fast growth continued to be so, until the leaves were primed on November 21 (Table 1). The plants in the 60 per cent saturation, however, were always a close second. Expressing in relative value the leaf products of green leaves of all the cultures on November 21 when the plants were first primed in the ascending order of per cent saturations were: 25, 35, 52, 66, 84, 99, 100, 70, 43, and 13. It is evident, therefore, that the optimum percentage of saturation for growth development of tobacco lies between 60 and 70. At earlier stage of growth development 60 per cent saturation was best but toward blossoming period 70 per cent was found to be better. The results of second trial conducted at another time of the year (Table 2 and Fig. 2) corroborate this finding. Javier (1936) also found in the case of sugar cane that cultures that had 60 and 70 per cent saturations were not only the highest producers of suckers, but also the two best cultures under all the criteria on the number of leaves, height of plants, length of stem and of roots, diameter of stem, fresh weight of shoots, weight of dry roots, weight of sun-dried shoots, and dry weight of the whole plant. Based from these findings, it is evident that in the soil a proper balance between the amount of water and air should exist to abound among the numerous rootlets of plants like tobacco and sugar cane and this state of condition could be attained when the percentage of soil moisture saturations is between 60 and 70.

EFFECT OF SOIL-MOISTURE UPON THE FINAL MAKE-UP

Appearance of plants at priming period.—An examination of Table 3 reveals the fact that the stature and color of the leaves of the plants under different percentages of saturations were very different. Figure 3 shows that the plants at 70 per cent saturation were the tallest (159 cm.) and those at 100 were the shortest (37.5 cm.). Likewise, varying amounts of soil-moisture in the medium effected color variation of fresh leaves. The color of leaves of the plants grown in 10, 20, 30, 40, and 50

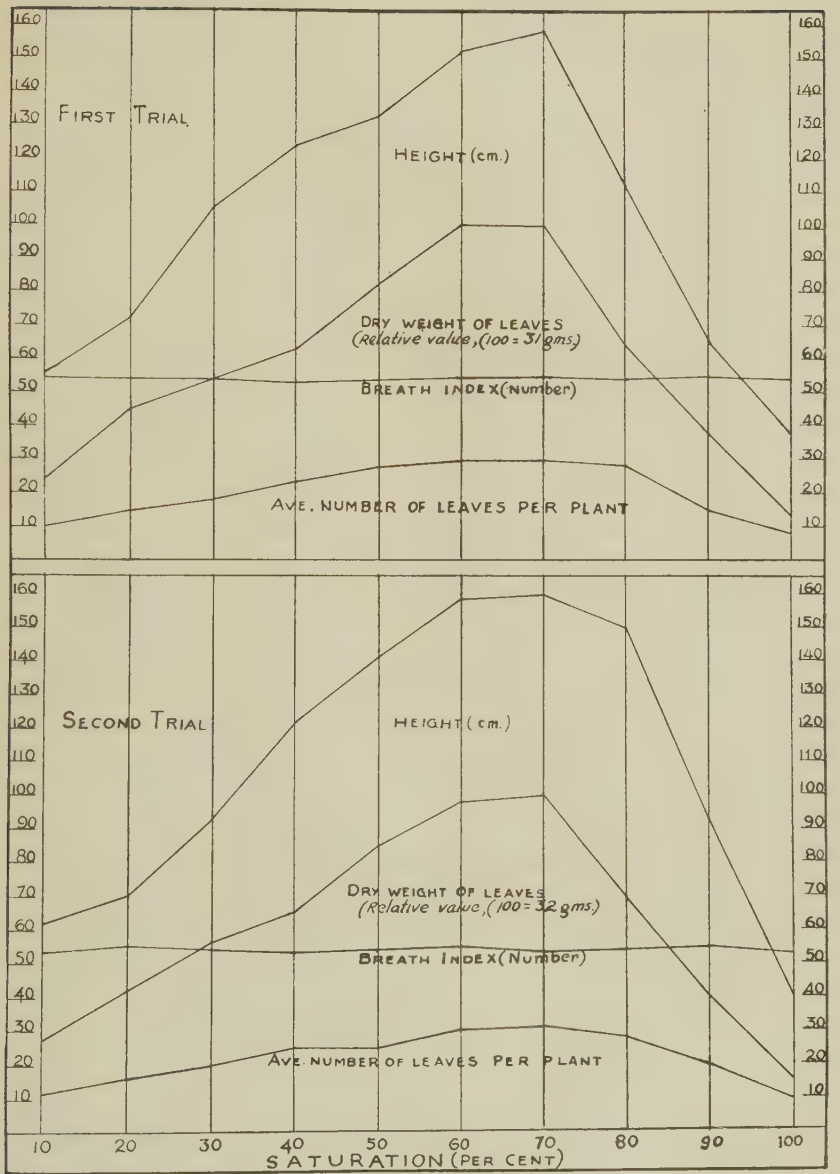

FIG. 3. Graphs showing effect of varying the moisture content of sandy loam soil in pots upon the development of tobacco plant.

per cent saturations was grass-green, those at 90 and 100 was pale yellowish-green and those at 60, 70, and 80 was of intermediate tone of green color between pale yellowish-green and grass-green.

Flowering.—The results of two trials conducted under greenhouse conditions show that earliness of flowering was influenced by the amount of soil moisture present in the medium. This was evidenced by the fact that the tobacco plants grown in the 60 and 70 per cent saturations in the two separate trials flowered first and followed by those planted at 50 and 80. The plants at 10, 20, 30, 40, 90, and 100 per cent saturations did not flower up to the time when the last harvest was done (Tables 1 and 2).

Number of leaves.—The number of leaves developed from each plant shows direct correlation with the vigor of the plant. David (1925) found also positive correlation between total number of leaves and height of plants. Under greenhouse conditions the tallest and most vigorous plants were those planted in the 60 and 70 per cent saturation (Fig. 3) and each plant had an average number of thirty leaves. Those plants grown in the 10 and 100 per cent saturations had very poor growth and produced only about one-third as much leaves per plant (Table 3). It is very probable that some of the initiating cells for the formation of leaves that arise close to the apex of the stem failed to divide due to very poor growth caused by either insufficient water content in the medium or due to inadequate amount of soil air as was the case in the 100 per cent saturation. The lack of water supply in the 10 per cent saturation was shown by the fact that the leaves wilted almost daily about the middle of the day (Tables 3 and 4). This condition of the leaves was detrimental to the normal progress of photosynthesis and finally to the growth development of the plant. According to Sach and Nagamatsz (1888), cited by Palladin, no starch is formed by wilting leaves, a fact which Stahl (1894), also cited by Palladin, believed to be due to the stomatal closure that accompanies wilting. It is very apparent, therefore, that the poor growth of the plants in the 10 per cent saturation resulted in the production of only few leaves which was due principally to the aggregate effect of interrupted water absorption and photosynthesis.

Size and shape of leaves.—Although the tobacco plants were grown under varying amounts of soil-moisture, the shape or form of the leaves did not change. This is shown by the constancy of the ratio obtained by dividing the width of the leaf by its length and the quotient multiplied by 100 (Tables 3 and 4). This ratio is called "Breadth Index." Figure 2 shows

plainly that in the graph for breadth index of all the cultures when plotted against percentage saturations, a line which is almost "straight" is formed. Under greenhouse conditions, unlike the effect of varying amounts of water vapor in the atmosphere, the water content of the soil even if present in varying amounts in the medium did not modify the shape of the tobacco leaf. However, the size of the leaf blades was greatly changed depending of course upon the amount of water present in the soil. The poor plants were those grown in the 100, 90, 40, 30, 20, and 10 per cent saturations and all had small leaf blades. The most vigorous plants were those grown in the 60 and 70 per cent saturations and also had the biggest leaf blades (Tables 3 and 4). If we consider the 10, 20, 30, and 40 per cent saturations as dry soil and the 60 and 70 per cent saturations as moist soil, then the result of this experiment confirms the finding of Kohl on *Tropaeolum majus* (see Palladin, 1914) that when the plants were cultivated in moist and dry soil and the external condition of the air was dry (both cultures) the relative sizes of leaf blades were 4 for the former (moist) and 1 for the latter (dry).

Average yield per plant.—The effect of various constant soil-moisture upon the growth of tobacco plant is finally expressed by the total yield per plant. Table 3 shows that the heaviest yield of cured leaves was obtained from cultures grown in 60 or 70 per cent saturations. In the second trial observation (Table 4) the heaviest yield was obtained in the 70 per cent saturation. Those that were grown in the 60 per cent saturation were close second. Kiesselbach (1916) also obtained in the case of corn a maximum production of dry matter when the water content of the soil was at approximately 70 per cent saturation. Tobacco plants grown in wetter soil over 70 per cent saturation and drier soil less than 60 per cent had poor yields (Fig. 2). The poorest yield was obtained in the 100 per cent saturation and the next poorest was from the 10.

EFFECT OF SOIL-MOISTURE UPON QUALITY AND CHEMICAL CONTENT OF TOBACCO LEAF

Cured leaves of tobacco plants grown in the 60 and 70 per cent saturations had light green color, pliable, and finely textured. Those plants in the 80, 90, and 100 per cent saturations had leaves that were yellowish-red, coarse, and not elastic. And

from the plants grown in 10, 20, 30, 40, and 50 per cent saturations the leaves after curing possessed dark-brown color, rough in texture, and non-pliable.

Color of ash.[a]—Tobacco leaves with white ash are preferred and the whiter the color of the ash the better is the leaf. The amount of soil-moisture in the medium affected the color of the ash. Leaves of plants grown in the 100, 90, 80, and 10 per cent saturations were pallid quaker drab (45 per cent white) and those in the 60 per cent saturation the color of the ash was pale dull gray (70 per cent white). The leaves of plants grown in the 50, 40, 30, and 20 per cent saturations had pallid mouse gray color of ash (45 per cent white) and the color of the ash from those in the driest medium, 10 per cent saturation, was pale mouse gray (22.5 per cent white).

Burning quality.—The glowing capacity of tobacco leaves depends principally upon two factors: first, the moisture content of the leaf and second, its total chemical composition. The effect of the first factor upon the burn is obvious and it is interesting to note that tobacco plants grown in the relatively dry soil with soil-moisture ranging from 10 to 50 per cent saturations had higher percentage of moisture content than plants grown in the wetter soil. Consequently, the former had poorer glowing capacity than that of the latter (Table 5).

Chemical content.—Table 5 shows that leaves of tobacco plants grown in the 100, 90, 80, and 70 per cent saturations contained less nitrogen (dry basis) than those in the relatively dry medium (10, 20, 30, 40, 50, and 60 per cent saturations). The first group had an average of 0.51 per cent nitrogen (dry basis) while in the latter the amount of nitrogen content averaged 1.34 per cent. This finding corroborates the results of Breaves and Carter (1923) who also observed a decrease in the nitrogen content of wheat, oats, and barley when the irrigation water used in their growth was increased. But whether the amount of nitrogen content of the leaf has an effect upon the glowing capacity of the leaf, this paper does not attempt to determine. However, the results gathered seem to indicate that leaves with poor glowing capacity have high percentage of nitrogen and those with hight glowing capacity have very low percentage. It appears, therefore, that if nitrogen is in excess, the quality of the leaf (glowing capacity) will likely suffer.

[a] The color of ash was determined by using Ridgway's color standards and nomenclature.

Table 5 shows further, that the amount of nicotine present in the samples analyzed varied greatly depending upon the amount of soil-moisture present in the soil. Nicotine was not detected from the amount of samples used from plants grown in the 100, 90, 80, and 70 per cent saturations. Only 0.92 per cent of nicotine (dry basis) was noted from the samples of leaves grown in the 60 per cent saturation and those in the 10, 20, 30, 40, and 50 per cent saturations had nicotine ranging from 1.24 to 2.26 per cent. It is also very interesting to note that when the amount of nitrogen was high in the sample there was also noted a high amount of nicotine, and when the nitrogen content of the leaf was low there was also very low amount of nicotine. The burn, flavor, aroma, and other important qualities of tobacco according to Garner are in no sense proportional to the amount of nicotine present. But, whether nicotine is a direct synthetic substance or a decomposition product of protein, the writers do not know. However, it is noteworthy to learn that relatively dry soil (10 to 50 per cent saturations) favored the production of relatively high amount of nitrogen and nicotine in the tobacco leaf. In the wetter cultures (from 60 to 100 per cent saturations) there were less nicotine and nitrogen found in the leaf (Table 5).

CONCLUSION AND RECOMMENDATION

Under greenhouse conditions, potted tobacco plants grew best when the range of soil moisture in sandy loam soil was between 60 and 70 per cent saturations. They did not only produce the heaviest yield but also the leaves raised had the best quality. Plants grown in the 10, 20, 30, 40, and 50 per cent saturations had leaves with very poor glowing capacity and the leaves also contained high nitrogen and nicotine content. In the 80, 90, and 100 per cent saturations, the amounts of nitrogen and nicotine contents of the leaf were low and the duration of glow was long, but the leaves were yellowish-red, coarse, and non-elastic.

Percentages of soil moisture lower than 60 and higher than 70 per cent saturations were found unfavorable to both, growth and yield of tobacco plants. For practical purposes if irrigation is practiced, this degree of saturation is judged in the case of sandy loam soil by taking a handful of the soil to be tested and gripe it loosely. Upon opening the hand the soil particles will hold together and also leave an impress on the palm.

Under these conditions the amount of water in the soil is approximately between 60 and 70 per cent saturation. The soil, therefore, for tobacco raising, particularly of the wrapper type, must be well drained and at the same time it must be of such quality as not to part with its moisture too easily in a period of dry weather.

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ILLUSTRATIONS

TEXT FIGURES

SOME NOTES ON MAKAPUNO COCONUT AND ITS INHERITANCE

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THREE PLATES AND ONE TEXT FIGURE

The inheritance of the makapuno character in coconuts offers an inviting field for study. Results of such study will not only interest the plant breeders but also give information of great practical value to the coconut growers who intend to raise makapuno nuts in a large scale. So far as the writer knows there is yet no published work regarding its inheritance.

This paper contains some results of field observations on the distribution and inheritance of makapuno coconuts, which began in 1929, together with some suggestions relative to the selection of the makapuno seed nuts and how the production of makapuno nuts might be increased. In order to augment the previous findings, it was necessary to undertake further observations to obtain more field data.

THE MAKAPUNO COCONUTS

The *makapuno* is a special type of coconut, Plate 1(*a*) in which the meat almost fills the cavity of the shell; hence, the name in Tagalog, "makapuno," meaning filled. Instead of a hard and crispy meat and milk found inside ordinary coconuts, Plate 1(*b*) there are in the makapuno nuts an outer portion which is white and soft substance corresponding to the meat of ordinary nuts and, in the inner portion a viscuous liquid, somewhat transparent or pellucid. It has been noted that the quantity of this viscuous inner substance seems to vary inversely with the age of the nuts.

Gonzales [1] (1914) gave in part the analysis of the two types of nuts as shown in the table below. These data were calculated to water-free basis.

[1] Gonzales, B. M. The makapuno coconut. Phil. Agr. and Forester 3 (1914) pp. 31–32.

TABLE 1.—*Analysis of ordinary nuts and makapuno nuts*

Composition	Ordinary nuts		Makapuno nuts	
	Meat	Milk	Firm outer portion	Soft inner portion
Water	63.62	95.13	71.59	90.66
Protein	9.09	7.09	11.76	10.69
Oil	68.63	(a)	41.67	18.89
Ash	2.11	(a)	1.81	3.74

[a] Undetermined.

The foregoing table shows that there is a considerable difference in the chemical composition of these two types of nuts; the makapuno is richer in protein content but poorer in oil.

In all outside appearances the makapuno bearing trees can not be distinguished from the ordinary coconut trees. However, at bearing age, they can be differentiated by the actual examination of the ripe nuts. A certain per cent of the nuts from the makapuno bearing trees are makapuno nuts. The makapuno nuts approach closely the size, shape and the color of the skin of the ordinary nuts either from the same bunch or from the same tree. As regards the makapuno nuts from different trees they vary in the color of the skin from green, red to almost yellow as the ordinary coconuts, and also in the size and shape of nuts, as well as in the amount of edible flesh in the nuts (Plate 3).

The makapuno nuts may be distinguished from the ordinary nuts by shaking and tapping the nuts when they are sufficiently mature. Usually, the makapuno nuts being filled, or almost so, do not produce any sound when shaken, though some of them may give the characteristic sound of a thick liquid within. By tapping, the makapuno nuts give also a characteristic "filled" sound, so that an adept in selection can pick them out by shaking and tapping with great precision.

DISTRIBUTION OF MAKAPUNO BEARING COCONUT TREES

Most of the makapuno nuts are raised in Laguna Province particularly in the barrios of Santo Angel or Ilog, San Lorenzo or Saluyan, and San Antonio or Balanga, municipality of San Pablo. A good number are also produced in the barrios of Cabanbanan and Sabang, municipality of Pagsanjan. Some makapuno nuts may be found in Dolores and other municipalities in Tayabas Province. A small number of makapuno nuts are

being raised in the Provinces of Batangas, Cavite, Pangasinan, in the Visayas, and in Davao. However, this type of coconut is hardly known in nothern Luzon, in some of the Bicol regions, in Capiz, in Zamboanga, in Basilan Island, and in many other places.

Most of the present supply is consumed in the City of Manila where it is best esteemed in the form of sweets. It is also made into ice creams, candies, and many other preparations. The possibility of raising makapuno coconuts in a large scale is very great as it commands a high price in the market, from 15 to 20 times or more than that of the ordinary nuts.

POLLINATION AND ITS RELATION TO NUT PRODUCTION

Before considering the inheritance of the makapuno character in coconuts it is essential to consider briefly the process of pollination in coconut. According to Mendiola[1] (1926) there are three forms of pollination in coconut. The first one is between male and female flowers of the same cluster or *interfloral* pollination; the second, between flowers of different clusters of one and the same tree or *intercluster* pollination; and the third, between flowers of different trees or cross-pollination.

In coconuts the pollination between flowers of the same cluster or interfloral pollination is possible only with relatively few female flowers of a few trees, which become ready for pollination a day or two before all the male flowers in the same cluster fall to the ground. This fact accounts for the natural falling off of the majority of the undeveloped female flowers at such times when the intercluster pollination and the cross-pollination do not take place.

During favorable weather the flower clusters appear in overlapping succession thereby making intercluster pollination possible, of course aided greatly by insect, by wind, and by gravity; cross-pollination due to insects is not at all excluded. Under these circumstances many of the female flowers are fertilized so that unless some conditions, unfavorable to the normal development of the fertilized female flowers set in, large number of ripe nuts are produced. According to some information gathered, large number of makapuno nuts are obtained when the ripe nuts are produced in abundance. Apparently, both the interfloral and intercluster pollinations do not affect the normal

[1] N. B. Mendiola. A manual of plant breeding for the tropics. Bureau of Printing, Manila (1926) pp. 1–365.

ratio between the makapuno and the ordinary nuts produced, as both are akin to self-pollination.

Cross-pollination is the rule at such times when intercluster pollination is not possible as during the dry season when the trees are undernourished. A makapuno bearing tree cross-pollinated with pollen from ordinary trees will produce only one phenotype of nuts, i. e., ordinary or normal nuts. Such cross-pollination, therefore, tends to reduce the production of makapuno nuts.

In some of the makapuno plantations some trees are known to produce some makapuno nuts every time their ripe nuts are harvested. The owners call them "sure makapuno trees" or "*segurado*." Upon examination of the distribution of the trees in the plantations it was invariably found out that these trees are surrounded by other makapuno bearing trees, indicating that if a makapuno bearing tree is cross-pollinated with the pollen from another makapuno bearing tree the normal proportion between the makapuno and the ordinary nuts may not be altered. Likewise, some of the isolated makapuno bearing trees free from any cross-pollination with pollen from ordinary coconut trees are found to produce some makapuno nuts more or less regularly.

INHERITANCE OF THE MAKAPUNO CHARACTER

The importance of this type of coconut has long been recognized by some of the planters in the Provinces of Laguna and Tayabas. At present there are some plantations as old as 60 to 70 years in which some of the trees are bearing makapuno nuts. In some younger plantations, however, some of the makapuno bearing trees are purposely planted in groups. These trees were grown from seeds borne with makapuno nuts in the same clusters, thus indicating that some of the coconut planters had already realized the fact that the makapuno type is an inherited character.

METHODS OF PROCEDURE

Two sets of field studies were conducted to determine the inheritance of the makapuno character in coconuts. The first one was by counting and determining the ratio between the ordinary nuts and the makapuno nuts produced by some of the known makapuno bearing trees. The second set consisted of determining the ratio between the ordinary trees and the makapuno

bearing trees in some of the established plantations consisting of trees grown from seeds raised from the makapuno bearing trees.

RESULTS

The number and the relative proportions of the two kinds of nuts are given in Table 2. In this connection, there are two conditions that must be stated in order to appraise properly the data shown in the table. First, that the data were obtained from the uncontrolled setting of nuts, that is, no artificial self-pollination was done, and second, that for some obvious reasons only the data from trees producing some makapuno nuts at the time of harvesting were considered.

TABLE 2.—*Segregation of nuts into ordinary and makapuno nuts*

Number of trees	Ordinary nuts	Makapuno nuts	Deviation 3:1 ratio	Probable error	Deviation probable error
6	34	9	1.75	±1.92	.9
9	48	12	3.00	2.26	1.3
24	174	35	17.25	4.22	4.1
3	50	12	3.50		1.5

The observed segregation of trees in the two established plantations studied are given in Table 3. In this observation only those plantations with makapuno bearing trees already marked in order to identify them from their sister normal trees were studied.

TABLE 3.—*Segregation of trees into ordinary and makapuno bearing trees*

Total number of trees	Ordinary trees	Makapuno bearing trees	Deviation 1:2 ratio	Probable error	Deviation probable error
60	27	33	7	±2.46	2.8
153	46	107	5	3.63	1.4
Total 213	73	140	2	4.64	0.4

DISCUSSION OF RESULTS

Makapuno nuts are produced from makapuno bearing trees so frequently that any geneticist would suspect at once that the makapuno character might be inherited in a mono-Mendelian fashion. Theoretically, in this type of inheritance the ripe nuts would segregate into two phenotypes in the proportion of 3

normal or ordinary nuts to 1 makapuno nut. A study of the data presented in Table 2 evidently will show that the mono-Mendelian theory of inheritance of the makapuno character is more or less substantiated, for 3 out of 4 cases gave deviations almost equal to their respective probable errors, indicating relatively high probability that such deviations would occur due to random sampling.

Case No. 3, however, showed a large deviation of 17.25 ± 4.22 nuts from the expected 3:1 proportion. This deviation is not very surprising as it has been stated above that all these data were obtained without artificial self-pollination and that there might have taken place in bloom cross-pollination with the pollen from the normal or ordinary coconut trees which tended to reduce the makapuno production. Another source of error may be mentioned in this particular case. Some of the doubtful makapuno nuts might have been classified with the normal nuts.

Let it be assumed that the makapuno type of coconut is a mono-Mendelian character, therefore, the genotypic segregation of nuts would be in proportion of 1 (MM) normal nut to 2 (Mm) hybrid nuts, otherwise normal nuts to 1 (mm) makapuno nuts following a monotypic ratio of 1:2:1, respectively (Plate 3). The first 2 biotypes are normal nuts as regards germinability but the first one will develop into a tree producing only normal nuts and each of the second biotype will grow into makapuno bearing tree. Theoretically, therefore, the mono-Mendelian 1:2 ratio of the normal and the makapuno bearing trees respectively, must be existing in the established makapuno plantations.

Segregation of trees.—Without reference to the field data presented in this report the author has obtained from a number of makapuno growers some information on the relative proportion between the ordinary trees and the makapuno bearing trees in their plantations. Their answers were interesting in that they seem to agree to the mono-Mendelian segregation. In fact one of the planters having a number of about 40 to 45 years old makapuno plantations consisting of no less than 3,000 trees has given the information that about 2,000 of his trees had actually produced some makapuno nuts.

In a plantation in barrio Putol, San Pablo, Laguna, containing 60 bearing trees of about 48 years old, there were 27 ordinary coconut trees and 33 makapuno bearing trees (see Table 3). According to the mono-Mendelian inheritance the expected proportion of the basis of 1:2 ratio is 20 ordinary to 40 makapuno

bearing trees, whereas the observed proportion was 27:33, thus, having a deviation of 7.00±2.46 trees or 2.8 times its own probable error showing a probability of 5.9 times in 100 trials that such a deviation may be expected to occur.

A counting made in another plantation (Fig. 1) of about 50 years old in barrio Ilog or Santo Angel of the same municipality, showed that there were 46 ordinary to 107 makapuno bearing trees with a deviation 5±3.63 trees from the expected 1:2 ratio. Here the deviation is 1.4 times its own probable error with a

M O O M M M M O M M O O O
M M O M M M M M M O O O O
M d M M M M O M M M M M M
M M O O M M M O M M M M M
M M O O M M M M M M O M
M M O O O M M M M M O O s
M M M O O d M M O O M M M
M M M M M O M O O M M d M
M M M M M O O M M M M M M
M M O O M M M M M M O M d
M M M O M M O M M M M O O d
O O O M M M M O M M M O M O

FIG. 1. Diagrammatic planting plan showing the distribution of the ordinary (O) and the Makapuno (M) bearing trees in the plantation of Don Miguel de la Rama, in barrio Santo Angel (Ilog), San Pablo, Laguna, (d) dead and (s) non-bearing tree.

probability of 34.5 in 100 trials. Considering the two cases together, the observed proportion of the ordinary to the makapuno bearing trees is 73:140 trees, respectively, whereas the expected proportion on the basis of 1:2 ratio is 71:142 with a deviation of 2.00±4.64 trees. Here the deviation is even smaller than the probable error.

Although the data on the segregation of nuts were obtained without artificial pollination, it is interesting to note that three

out of four cases are in close agreement with the 3:1 ratio of the mono-Mendelian type of inheritance. Furthermore, the 1:2 proportion between the normal trees and the makapuno bearing trees found in the established makapuno plantations proved further that the makapuno type is of mono-Mendelian character.

SELECTION OF MAKAPUNO SEED NUTS

The planting of seedlings from makapuno bearing trees should be encouraged, not only because the makapuno nuts command a good price in the market, but also on the basis of a sound speculation on the possibility of establishing a more or less lucrative industry that might result from a large production of makapuno nuts.

It has been the common practice of the planters to select for makapuno seed the nut at the tip or *"pusod"* of each bunch having one or more makapuno nuts. Others contend that the nuts nearest the makapuno in the bunch should be selected for seed. The latter may be more reasonable than the former, as the nuts nearest the makapuno had the greatest chance to be fertilized by pollen from the same bunch of flowers if not from the same flowers which produced the pollen that impregnated the makapuno nuts. How these nuts taken from different portions of the same bunch will breed with respect to makapuno character cannot at present be said. It is very doubtful if the results of such experiment, if conducted, would compensate the trouble that would be involved. According to the present observation, all good sized and well developed nuts in the same bunch with makapuno and from a tree which is more or less a regular bearer of makapuno nuts, may be used for seeds; and two-thirds of the seeds so taken may be expected to develop into makapuno bearing trees.

It was stated that there are two genotypes of seed nuts coming from a makapuno bearing tree. These genotypes have been designated as type *MM* and type *Mm* which may be expected to occur in the proportion of 1: 2, respectively.

Theoretically, a makapuno bearing tree being a mono-hybrid, produces two kinds of female flowers or ovaries: the *M* normal ovaries and *m* makapuno bearing ovaries, in 1:1 proportion. If these ovaries were fertilized by pollen from a normal coconut tree, only two combinations are formed, the *MM* normal nuts and *Mm* hybrid nuts in the proportion of 1:1 and this accounts for the fact that cross-pollination of the makapuno bear-

ing trees by the normal trees tends to reduce the production of makapuno nuts in the former.

It might be mentioned in this connection that a normal tree may also give rise to a makapuno bearing seedling when by chance one of its ovaries had been cross-pollinated by a makapuno bearing pollen *m* from a makapuno bearing tree.

In the selection of makapuno seed nuts the important points to consider are the regular bearing habit, the size of nuts or the quantity of edible portion in the nuts, and the seeds taken from the clusters with one or more makapuno nuts.

INCREASING MAKAPUNO PRODUCTION

There are various ways that might be suggested to increase the production of makapuno coconuts. One way is to improve the condition of the trees by manuring or fertilization, thereby making it possible for the flower clusters to appear in overlapping succession so that the intercluster pollination can take place. Another which might be a less practical method is by artificial pollination with the pollen from trees that are also bearing makapuno nuts, preferably from sister trees.

The removal of the normal or non-makapuno bearing trees from the established plantations might result in an increase production of makapuno nuts, for by so doing the cross-pollination from such trees which tends to reduce makapuno production will be eliminated. This idea gives rise to a new system of planting which may be suggested to any prospective makapuno grower, that is, to plant the makapuno seed nuts in groups of 2 or 3 seeds per hill and distanced at 12 to 15 meters each way between groups. Later on, the normal trees which do not produce makapuno nuts, about one-third of the total number, may be removed without considerable loss in the production of the whole plantation.

Another though quite a remote possibility of increasing makapuno yields is to find some means to germinate the embryos found in the makapuno nuts. It is believed that these embryos are alive but unable to germinate under the ordinary method of germinating seed coconuts. Its failure to germinate is most probably due to lack of "milk" necessary to maintain the germination of the embryos as in the case of normal nuts. It was observed that even the normal nuts failed to germinate whenever the water in the nuts had been excessively reduced.

The problem of germinating the makapuno embryo is an important subject for physiological study in the laboratory which has been barely started. In all probability the makapuno type is a homozygous recessive character, so that the absence of cross-pollination with the other types will bear all makapuno nuts. Unless the makapuno embryos are inherently weak or incapable of germination or of continuous vegetative growth it is reasonable to expect that all efforts to germinate them in the laboratory will come out successful in the end.

SUMMARY

The data presented in this paper indicate strongly that the makapuno character in coconuts is inherited in a mono-Mendelian fashion. Being recessive to its normal allelomorph the makapuno bearing trees are heterozygous for the makapuno character. The normal nut has been designated as *MM* type; the heterozygous or makapuno bearing coconuts as *Mm* type; and the makapuno nut as *mm* type.

In the light of the results obtained it becomes evident that there are two biotypes of trees coming from the makapuno bearing trees, the normal trees of the *MM* type and the makapuno bearing trees of the *Mm* type, which actually exist in the established makapuno plantations in the proportion of approximately 1:2, respectively.

The size of nuts, the quantity of the edible portion in the nuts, and the regular bearing habit are the points to be considered in the selection of makapuno seed nuts.

Increasing the makapuno production by manuring or fertilization, artificial pollination whenever practicable, and by the removal of all the non-makapuno bearing trees from the makapuno plantations are suggested. A new method of planting a makapuno plantation for the same purpose is also stated.

Mention is made of the presence of live embryos in the makapuno coconuts.

The most outstanding practical value of the results so far obtained from this study is the knowledge of the relative proportion between the normal trees and the makapuno bearing trees obtainable from the selected makapuno bearing mother trees. One may expect to get about 1,000 makapuno bearing trees from every 1,500 seedlings raised from seeds carefully selected from the makapuno bearing trees.

RECOMMENDATIONS

The collection of more data on the production and segregation of the makapuno nuts, monthly or bi-monthly, for a number of years in order to study the fluctuation of makapuno production and to determine the factor or factors concerned is recommended. If facilities and funds permit it is suggested that the inheritance study should be carried on further with artificial pollination. Besides, more field information on the segregation of trees in the established plantations should be gathered.

The germination of the makapuno embryo in the laboratory should be pursued as well as the allied microscopic study of its morphology. On the belief that the makapuno embryo is alive and homozygous for makapuno character, efforts should be exerted to germinate it to find out the possibility of producing a plant that might produce all makapuno nuts.

ILLUSTRATIONS

PLATE 1

FIG. 1. Makapuno coconut showing the embryo.
2. Ordinary or normal coconut showing the embryo.

PLATE 2

Different types of makapuno nuts.

PLATE 3

Illustrative drawing showing the inheritance of makapuno type of coconut. 1, ordinary or normal nut; 2 and 3, the heterozygous or the makapuno bearing type; and 4, the makapuno type.

TEXT FIGURE

FIG. 1. Diagrammatic planting plan showing the distribution of the ordinary (O) and the makapuno (M) bearing trees in the plantation of Don Miguel de la Rama, in barrio Santo Angel (Ilog), San Pablo, Laguna, (d) dead and (s) non-bearing tree.

1

2

PLATE 1.

PLATE 2

PLATE 3.

LINE SELECTION OF KHAO BAI SRI

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INTRODUCTION

The desire to improve plants is as old as agriculture. Desirable forms were preserved in the early days, and one of the outstanding examples of improved plant is the rice. Along this line it is recorded in the memoirs of the Manchu Emperor, K'hang-Hsi, that in 1662–1723 he did some selection work of a certain type of rice plant with fine grains.(1) This was propagated later on and became the source of his rice supply for 30 years.

The plasticity of the genus *Oryza* to which the cultivated rice belongs has given rise to the formation of thousands of varieties adapted under varied conditions.

REVIEW OF LITERATURE

According to De Vries, Le Couteur assumed in the early part of the eighteenth century that selected plants beget similar offspring. Patrick Shireff, in the middle part of the century, corroborated the finding of Le Couteur, working on exceptional plants to produce new varieties.

Johannsen, in his experiment early in the twentieth century, concluded that improvement within a pure line is futile. This is corroborated by other investigators, working on other crops and characters. Parnal and others reported (1917) that the natural crossing in rice varied from 0.1 per cent in one variety and 2.9 per cent in another variety (2), (4), and (5).

During the last seventeen years of continuous culture, since its introduction from Siam into the Philippine Islands(3) the Khao Bai Sri variety of rice has manifested inconsistency both in heading and production. It is a quality rice which is rated as first class, extra superior both in the Philippines and abroad.

Be it stated in passing, that the over-production of rice in the rice producing countries during the last half decade has brought about quality discrimination and gives impetus to the production of a good quality rice that is in demand both in local and foreign markets.

The pedigree selection was made in Alabang Rice Station, Muntinlupa, Rizal, in 1930 to 1933 inclusive, and the strain or final test was conducted in Maligaya Rice Station in 1934.

MATERIALS AND METHOD

In a propagation field planted to a mixed population of Khao Bai Sri nine desirable plants were observed and collected separately in 1929. In the following season (1930) the seeds from these plants were sown separately in seedbeds and were later transplanted in prepared paddies after six weeks. One hundred seedlings per row representing one elite were planted at a distance of 20 centimeters between hills. The different elites were planted in separate rows at a distance of 20 centimeters. Three check rows of the same variety consisting of mixed population were used. Two guard-rows were placed on both sides of the test plot and a check row was set between the fourth and the fifth rows of the elites to serve as basis for comparison. The whole test plot was, therefore, provided with border plants so as to exclude all possible border effects upon yields. In the successive years, however, the check rows were disregarded and only the elites were compared with each other, thus gradually eliminating them. The elites were numbered as 1247, which stands for P. I. number of the variety under study. P stands for plant and the suffixing figures stand for the number of the selected plant or elites in the order of planting in the row.

RESULTS

The yields of the different rows of elites in the first year of planting are shown in Table I. Elites 1247–P1 yielding 1,156 grams per row and six best plants were selected; 1247–P2 yielded 1,232.0 grams and four best plants selected; 1247–P5 yielded 1,070 grams and five best plants selected; and 1247–P9 yielded 1,287.0 grams and three best plants were selected. These selected elites yielded much higher than the average yield of the checks and still higher than any of the other three elites tested.

TABLE I.—*Showing the performance of the elites in the first year planting, 1930*

Elites	Yield of 100-plant row	Average yield of check rows
	grams	*grams*
Elite No. 1247–P1	1,156.0	
Elite No. 1247–P2	1,232.0	974
Elite No. 1247–P3	872.0	
Elite No. 1247–P4	918.0	
Elite No. 1247–P5	1,070.0	
Elite No. 1247–P6	848.0	
Elite No. 1247–P7	1,008.0	
Elite No. 1247–P8	1,004.0	
Elite No. 1247–P9	1,287.0	

The yields of the elites in the second year of selections are shown in Table II. Elites 1247–P1–1 with a yield of 1,583.3 grams to the row; 1247–P2–7 with a yield of 3,571.4 grams; and 1247–P9–1 with a yield of 1,786.7 grams were the highest yielders among the elites tested, and were then selected for planting in 1932 test.

TABLE II.—*Showing the yields of the elites in the second year tests, 1931*

Elites	Yield per row 100 plants	Remarks
	grams	
Elite No. 1247-P1-1	1,583.3	Selected for 1932.
Elite No. 1247-P1-2	1,326.5	
Elite No. 1247-P1-4	1,395.8	
Elite No. 1247-P1-6	1,322.9	
Elite No. 1247-P1-7	1,340.0	
Elite No. 1247-P1-10	1,656.2	
Elite No. 1247-P2-7	3,571.4	Selected for 1932.
Elite No. 1247-P2-8	1,410.0	
Elite No. 1247-P2-9	1,448.5	
Elite No. 1247-P2-10	1,418.3	
Elite No. 1247-P5-1	1,418.3	
Elite No. 1247-P5-2	1,367.3	
Elite No. 1247-P5-6	1,450.0	
Elite No. 1247-P5-7	1,510.4	
Elite No. 1247-P5-10	1,469.3	
Elite No. 1247-P9-1	1,796.7	Selected for 1932.
Elite No. 1247-P9-3	1,500.0	
Elite No. 1247-P9-10	1,357.1	

The materials of all the elites planted were harvested, dried, bundled separately and stored in the laboratory in 1932. Due

to lack of necessary helps the gathering of laboratory data was delayed and unfortunately the materials were badly damaged by rats. Thus the data secured could not be presented.

And because seeds and labor were limited and the planting season was already far advanced, only the seeds of the best elites were planted in the dapog seedbed and transplanted at the age of 12 days to catch up the loss of time. Of course, the treatment of sowing the seeds in the seedbed was different from the previous years, but the results of the 1933 crops helped in determining the best elites for strain test. The 1933 results are shown on Table III.

In Table III, the yields of the four best and high yielding elites are summarized.

TABLE III.—*Yield in grams of 100-plant rows of the different elites in 1930, 1931 and 1933*

Elites	Years tested				Average for 3 years
	1930	1931	1932	1933	
	Grams	*Grams*	*Grams*	*Grams*	*Grams*
Elite No. 1247–P2–7–1	1,232.0	3,571.4	----------	4,003.0	2,935.5
Elite No. 1247–P1–1–1	1,156.0	1,583.3	----------	2,543.3	1,760.9
Elite No. 1247–P1–10–6	1,156.0	1,656.2	----------	1,954.5	1,588.9
Elite No. 1247–P9–1–1	1,287.0	1,786.7	----------	1,592.7	1,555.3

The elites No. 1247–P2–7–1, 1247–P1–1–1, and 1247–P9–1–1 were included in the final test and compared with the original variety P. I. No. 1247 Khao Bai Sri, and the elite No. 1247–P9–1–1 has been eliminated from the strain or final test on account of its low average yield.

RESULTS OF FINAL TEST

Ten replications were made for each elite with an area of 1/40 acre or 1/200 hectare or 50 square meters each plot. The entire field may be described as irrigated plain or level and clay loam type with almost uniform soil condition.

All the seeds of selected elites including the seeds of the mixed population for checks were soaked on June 11, 1934, sown on June 13, 1934, and transplanted on July 30 to 31, 1934. Uniform treatments as to watering and weeding were given to all the plots. The results of the test are shown in Tables V and VI.

Elite No. 1247–P2–7–1 yielded 69.5±1.5 or 9.0±1.2 cavans per hectare more than the check; Elite No. 1247–P1–10–6 yielded 69.2±2.2 or 8.7±1.6 cavans over the check; and Elite No. 1247–P1–1–1 yielded 62.6±2.2 or 2.1±1.6 cavans higher than the check, whose difference in favor of the elite is quite insignificant.

TABLE V.—*Showing the yields of different strains of Khao Bai Sri, 1934–1935*

Strain number and plot designation	Actual yield of plot of 50 sq. m. (kilos)	Computed yield per hectare	
		Kilos	Cavans
1247–P2–7–1–A– 1	14.0	2,800.0	64.2
A– 2	14.0	2,800.0	64.2
A– 3	13.5	2,700.0	61.9
A– 4	14.5	2,900.0	66.5
A– 5	16.0	3,200.0	73.4
A– 6	14.0	2,800.0	64.2
A– 7	16.0	3,200.0	73.4
A– 8	18.5	3,700.0	84.8
A– 9	16.0	3,200.0	73.4
A–10	15.0	3,000.0	68.8

Mean: 69.5±1.5 cavans

1247–P1–1–1–B– 1	13.0	2,600.0	59.7
B– 2	10.5	2,100.0	48.2
B– 3	11.0	2,200.0	50.4
B– 4	15.5	3,100.0	71.1
B– 5	11.0	2,200.0	50.4
B– 6	13.0	2,600.0	59.7
B– 7	16.0	3,200.0	73.4
B– 8	15.5	3,100.0	71.1
B– 9	16.0	3,200.0	73.4
B–10	15.0	3,000.0	68.8

Mean: 62.6±2.2 cavans

TABLE V.—*Showing the yields of different strains of Khao Bai Sri, 1934–1935*—Continued.

Strain number and plot designation	Actual yield (kilos) per plot, 50 sq. m.	Computed yield per hectare	
		Kilos	Cavans
1247-P1-10-6-C- 1	14.0	2,800.0	64.2
C- 2	12.0	2,400.0	55.0
C- 3	17.0	3,400.0	77.9
C- 4	13.0	2,600.0	59.6
C- 5	12.5	2,500.0	57.3
C- 6	16.0	3,200.0	73.4
C- 7	18.5	3,700.0	84.8
C- 8	15.0	3,000.0	68.8
C- 9	15.0	3,000.0	68.8
C-10	18.0	3,600.0	82.6
Mean: 69.2±2.2 cavans			
Check-D- 1	11.0	2,200.0	50.4
D- 2	14.0	2,800.0	64.2
D- 3	14.0	2,800.0	64.2
D- 4	13.0	2,600.0	59.6
D- 5	13.0	2,600.0	59.6
D- 6	14.0	2,800.0	64.2
D- 7	14.0	2,800.0	64.2
D- 8	13.0	2,600.0	59.6
D- 9	14.0	2,800.0	64.2
D-10	12.0	2,400.0	55.0
Mean: 60.5±1.0 cavans			

TABLE VI.—*Showing summary of Table V*

Strain	Mean yield per hectare	Difference in increase over check	Remarks
	Cavans	*Cavans*	
Check:	60.5±1.0		
1247-P2-7 -1	69.5±1.5	+9.0±1.2	Significant.
1247-P1- 1-1	62.6±2.2	+2.1±1.6	Not significant.
1247-P1-10-6	69.2±1.0	+8.7±1.6	Significant.

CONCLUSIONS

Strain No. 1247–P2–7–1 from the initial selection to the completion of the test has shown consistently high yields. It yielded more than any of the other elites, and has given a significant difference of 9.0±1.2 cavans over the check in the final test. Strain No. 1247–P1–10–6 has shown similar productivity although slightly lower than the former strain. Strain 1247–

P1–1–1 yielded 2.1±1.6 cavans over the check, which increase is not significant.

RECOMMENDATIONS

1. Strains No. 1247–P2–7–1 and 1247–P1–10–4 may be used for commercial planting.

2. For best results, these strains should be planted only on areas that can be drained, and have medium to fairly good soil with irrigation facilities.

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UTILIZATION OF OUR IMPROVED NATIVE VARIETIES TO UTMOST ADVANTAGE FOR PROFITABLE TOBACCO PRODUCTION

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FIVE PLATES

The keen interest among our farmers in Central Luzon and in several provinces in the Visayan Islands in raising tobacco as one of their major crops is a sure sign that sooner or later tobacco growing will no longer be confined in the Cagayan Valley. It is important, therefore, that the farmers in these new tobacco regions be guided accordingly at the start to avoid or at least minimize failures and disappointments. A system of growing tobacco of the cigar and batek types with a better chance of earning a more decent profit than with the prevailing system of growing these types, is briefly described in this paper. Customarily, our tobacco farmers produce either a pure "liso" (cigar filler) or pure batek crop from their plantations and in a few instances a combination of batek and liso tobacco. This paper touches a new phase in tobacco production. It advocates producing more than one kind of tobacco crop from one plantation. This is made possible through the improvements made on two native varieties of tobacco which are now very appropriate for double and triple purposes. These two varieties are:

1. *Simmaba.*—This is a tall variety with a large stalk and medium-closed internodes. It reaches a height of from 200 to 250 centimeters and develops as many as from 18 to 36 leaves. The leaves are big, deep green when fresh, the width more than half the length, smooth, nearly erect, and from elliptical to nearly ovate in shape. The veins are medium-fine and approach an almost right angle position. The petiole is broadly winged. The standard leaves have an average measurement of from 78 to 104 centimeters in length and 46 to 68 centimeters in width. This variety is quite resistant to the wilt disease and can thrive under somewhat droughty conditions as in Ilocos. It is the best variety for wrapper purposes in shade culture.

This variety was discovered by the senior author about six years ago in the interior districts of La Union, grown by the highlanders in the mountainous district of the province. It was brought to the lowland and with the help of coöperators it was improved by selection for three seasons. The original growers themselves do not know how this type of tobacco came into their possession. According to Paguirigan, this variety is similar if not the same as the Marogui variety of the Cagayan Valley. Gutierrez advanced the opinion that the Simmaba must be a natural cross between the native variety which farmers in La Union call San Juan and the acclimatized Sumatra varieties. If the dominant external characteristics of the so-called San Juan and the Philippine Sumatra varieties are studied, one will find them present in the Simmaba. The Simmaba bears the shape, angle of venation and erect leaf position of the Sumatra when the leaves are not yet over-matured, and the size, deep green color of the leaves, and the late maturing habit of the San Juan variety. The characteristics of the Simmaba are well-pronounced when grown in La Union. Gutierrez' contention of the probable origin of this variety gains ground when one remembers that way back in 1918 to 1922, the Naguilian Tobacco Station of the old Bureau of Agriculture was growing and distributing various kinds of tobacco seeds including the Sumatra. Undoubtedly, the farmers may have grown the Sumatra side by side with their native tobacco. Natural cross-pollination under this condition was, therefore, possible. The farmers, not in the habit of bagging their mother plants naturally had in their stocks of seeds hybrids which, in the course of so many years of seasonal planting, have approached a high degree of purity. This variety upon being brought to the lowland was christened Simmaba because of its big-sized leaves.

2. *Vizcaya.*—This variety is a native of the Cagayan Valley and was improved and standardized by the Ilagan Tobacco Experiment Station in Ilagan, Isabela. It also grows very tall with large stalk but with longer internodes than the Simmaba. It reaches a height of from 220 to 250 centimeters and develops as many as from 22 to 38 leaves. The leaves are also big, light green in color, but the width is less than one-half the length. The leaf position is from horizontal to slanting, the petiole medium-winged, and the veins medium fine. The chief quality of this variety is its readiness to become light colored upon curing which gives it the desired color for wrapper. This variety is

preferable for shade culture under somewhat moist condition as in Laguna and Batangas.

PLANTING CIGAR FILLER TOBACCO FOR DUAL PURPOSES

When these two varieties described above are planted primarily for the production of cigar filler tobacco, the planting distances are set 70 centimeters between the plants in the row and 80 centimeters between the rows, or about 17,000 plants to the hectare. These planting distances enable the leaves particularly the standards to overlap intimately, thus naturally shading the sand leaves below. These sand leaves, because of their medium size are naturally thin, small-veined and fine in texture. The shade given them by the standard leaves above augments these qualities. Under prevailing practices these leaves are mostly allowed to deteriorate in the field or are destroyed during cultivation. Only in a few instances are they harvested together with the rest of the crop and when this is done they are already over-ripe, broken and soiled with earth. The buyers generally call these crop "terrozos" (soiled crop). If these sand leaves are picked at the proper time, poled and cured as wrapper leaves, they become the most valued portion of the entire production and certainly increase the income of the farmers without the necessity of increasing the expenses in production. These, should be picked before they reach complete maturity; poled face-to-face and back-to-back; and cured in a well ventilated curing shed. At least from four to six of the middle and lower sand leaves should be harvested, and from them three to six quintals of wrapper could be produced from a hectare of cigar filler plantation.

A hectare of cigar filler plantation under excellent conditions yields from twenty-five to thirty quintals of cigar filler if the sand leaves are also harvested as filler leaf. This gives an average of about 25 quintals to the hectare. At an average price of ₱10 a quintal of filler the gross income for every hectare is around ₱250. The average cost of production per hectare of cigar filler tobacco in the Philippines is around ₱230, giving the farmer a net profit of only ₱20 to the hectare.

Actual results now obtaining in the Tubao Valley, La Union, within the last six years clearly show that from a hectare of cigar filler tobacco plantation, at least 21 quintals of cigar filler and 4 quintals of medium fine wrapper, if the sand leaves are given care and picked and cured as wrapper crop, can be ob-

tained. These wrapper crops are usually sold locally at an average price of ₱25 a quintal. The buyers are mostly Chinese leaf tobacco dealers. It is very evident, therefore, that by converting the sand leaves as wrapper crop, the farmers can realize a gross income of about ₱310 to the hectare or a net profit of about ₱80 from a hectare of their cigar filler plantations which give them only ₱20 when only cigar filler crop is produced. It should be mentioned in this connection that the price of ₱25 a quintal of these wrappers derived from sand leaves is very low. If brought to the Manila market it will undoubtedly command a much better price. However, the quality of these sand leaves as wrapper and, consequently, their market value depend much upon the care given them. What is very important to remember is that they should be picked quite green and cured and graded accordingly.

PLANTING BATEK LEAF TOBACCO FOR TRIPLE PURPOSES

These two varieties when grown principally for batek leaf tobacco production are set in the field at one meter apart between the rows and 80 centimeters between the plants in the row. This is giving sufficient space for the expansion of the leaves and ample feeding area for the roots.

Originally, the batek tobacco industry was a monopoly of La Union and Northern Pangasinan while Ilocos Norte produced most of what was consumed locally. During the last two years, however, other provinces like Nueva Ecija, Laguna, and Batangas ventured in the production of this type of tobacco with fair results. The present practice of growing batek consists in producing it from the standard leaves only. Sometimes a little crop of cigar filler is obtained from the sucker leaves but in most cases none at all. The sand leaves are allowed to decay in the field or, when harvested, are classified as "terrozos." To get the full benefit and reward of their labor the farmers should get three kinds of tobacco crop from their batek plantations, viz:

First, wrapper crop should be obtained from the sand leaves which are only being destroyed in the field or are harvested as inferior grades of cigar filler. This is easily done by harvesting them at the proper state of maturity and curing them at a finger distance in a well-ventilated curing barn.

Second, when all the sand leaves are harvested, the plants are topped allowing only eight to ten standard leaves to remain for the production of batek. Topping in this case is not like pinch-

ing the buds as it is done in topping cigar filler tobacco. Topping should be done early and when the plants are most vigorous in growth and long before the flowering season sets in. Whatever leaves remain are allowed to mature and are only harvested when those famous yellowish brown spots called batek become well pronounced. At this maturing stage suckers are not allowed to develop.

Third, after all the batek leaves are harvested, two to four suckers are encouraged to grow for the production of cigar filler tobacco. These suckers or branches are again topped to encourage their development. The original plants having been topped early enough will naturally grow big branches with well-sized leaves which are still very ideal for cigar filler purposes.

From a hectare of good batek tobacco plantation an average of 4 quintals of wrapper, 20 quintals of batek and 8 quintals of cigar filler leaf tobacco can easily be harvested. At an average price of ₱25, ₱20 and ₱9 a quintal of wrapper, batek and cigar filler crops respectively, a hectare of good batek tobacco can give a gross income of ₱572 or a net profit of about ₱349.50, if the cost of production per hectare is ₱222.50. If only batek is produced the net profit is ₱177.50, or ₱172 more profit in favor of the triple purposes. If batek and cigar filler are produced the net profit is around ₱249.50, or ₱100 less gain where the three crops are produced.

PRODUCING PURE WRAPPER CROP BY SHADING

The production of pure wrapper crop from these two varieties is effected by the use of artificial shade. Palm leaves, talahib grass, and abacá cloth are among the cheapest and most common materials now being used by wrapper growers. The production of this highly specialized product requires bigger outlay of capital and a great deal of technical knowledge which can only be acquired by experience. The average cost of production under Philippine conditions ranges from ₱600 to over ₱1,000 depending much upon the locality. At the present average prices of shade-grown wrapper, ranging from ₱4 to ₱2 a kilo, and the yield ranging from 12 to 16 quintals to the hectare, the gross income is big amounting to from ₱1,800 to ₱2,400 per hectare. The net income, however, will depend upon the cost of production which is variable. With the exception of a group of independent small farmers in La Union and Isabela, practically all the wrapper growers at the present time are confined to the big

landowners and capitalists. Present experiences show that even with the sufficiency of capital, it is hardly possible for even the big producers to start bigger production, due to the scarcity of trained specialists along this line. The rapid development of this new industry will depend mostly upon the ability of the young managers engaged by the big growers to equip themselves with the necessary technical skill through experience.

GENERAL REMARKS

The successful production of wrapper leaf tobacco subsidiary to the main or principal crop of either cigar filler or batek is not only a possibility but has long been a reality. In the Cagayan Valley and in La Union Province wrapper tobacco of fair quality has for a long time been produced by the farmers from the sand leaves of their cigar filler or batek tobacco plantations. This is done in spite of the little attention given to the crops, specially with regard to the degree of maturity of the leaves when harvested and the curing method employed. These crops are sold to the buying firms not as wrapper but as filler tobacco. Once bought the buying firms reclassify the leaves, grade them accordingly and are sold to the tobacco factories as cigar wrapper. The writers are aware of two prominent tobacco dealers in Manila who are selling this type of wrapper tobacco at prices ranging from ₱70 to ₱100 a quintal of 46 kilos. The biggest factories in Manila with big haciendas in the Cagayan Valley are utilizing a big volume of wrapper derived from the sand leaves of their cigar filler tobacco plantations in that region.

There are numerous other native tobacco varieties being grown in many parts of the Philippines. Undoubtedly, these have some qualities that are desirable. Most, however, are deficient in quality for wrapper purposes. The improved varieties, Simmaba and Vizcaya, besides possessing the excellent qualities for cigar filler and batek tobacco, are also the most ideal for the production of wrapper either in shade culture or in open culture.

Having the right soil and climatic conditions coupled with a more progressive method of culture and curing processes, the tobacco farmers, particularly the small producers, can increase their income without the necessity of increasing their cost of production by growing these two improved varieties for double or tripple purposes. Here lies one of the secrets of raising tobacco with profit-producing of two or three kinds of crop from one plantation.

For a more detailed information regarding the culture of cigar filler, cigar wrapper, and batek leaf tobacco, the readers are referred to the Farmers' Circular Nos. 15, 17, and 18 of the Bureau of Plant Industry. These circulars are distributed free of charge upon request.

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TABLE 1.—*Cost of producing one hectare of cigar filler with cigar wrapper leaf tobacco as secondary crop*

1. Preparation and sowing of seedbeds..... September and October
2. Transplanting season..... November and December
3. Harvesting season..... February, March, Apr. May
4. Distances of planting..... 80 cms. × 70 cms.
5. Number of plants to the hectare..... 17,750
6. Estimated yield per hectare..... 1,250 kilos or 25 quintale

	Man	Woman	Animal	Approximate cost
	Days	*Days*	*Days*	*Pesos*
1. Curing barn of light materials worth ₱150.00 (6 m. x 12 m. x 3 m.) to last for three years				50.00
2. 1,000 palillos				10.80
3. 200 grams of seeds				1.00
4. Preparation and sowing of seedbeds 20 beds each of 1 m. x 10 m.	8		8	8.00
5. Rearing of seedlings up to transplanting time	5	10		7.00
6. Preparation of field three plowing and 3 harrowing	12		12	14.00
7. Transplanting	10	30		17.00
8. Three times cultivation	8		8	9.00
9. Worming, topping and suckering		40		12.00
10. Harvesting	5	60		22.00
11. Poling and sticking	10	80		32.00
12. Barn operation		10		7.00
13. Fermentation	4	10		6.00
14. Bundling and classification		80		24.00
15. Incidentals				10.00
Total expenses				229.80

Approximate yield per hectare if cigar filler is only produced, 1,250 kilos or 25 quintales at ₱10 a quintal..... 250.00
Total expenditure 229.80

Net gain 20.20

Approximate yield per hectare if cigar filler and wrapper crops are produced—
(*a*) 4 quintales of wrapper at ₱25 each..... 100.00
(*b*) 21 quintales of cigar filler at ₱10 each..... 210.00

Gross income 310.00
Total expenditure 229.80

Net gain 80.20

TABLE 2.—*Cost of producing one hectare of batek leaf tobacco with cigar filler and cigar wrapper as secondary crops*

1. Preparation and sowing of seeds..... September and October
2. Transplanting season..... November and December
3. Harvesting season ..... March, April, and May
4. Distances of planting..... 1 m. × 80 centimeters
5. Number of plants to the hectare..... 12,500 plants
6. Estimated yield per hectare..... 20 quintales batek

Items of operation	Man	Women	Animal	Approximate cost
	Days	*Days*	*Days*	*Pesos*
1. Curing barn of light materials worth ₱150.00 (6 m. x 12 m. x 3 m.) to last for three years				50.00
2. 1,000 palilos				10.00
3. 200 grams of seeds				1.00
4. Preparation and sowing of 18 seedbeds each of 10 sq. m. area	7		7	7.00
5. Rearing of seedlings to transplanting	4	8		6.00
6. Preparation of field 3 plowing and 3 harrowing	12		12	14.00
7. Transplanting	8	28		13.20
8. Three times cultivation	8		8	9.60
9. Worming, topping, suckering		35		10.50
10. Harvesting	5	60		22.00
11. Poling and sticking	10	80		32.00
12. Barn operation		10		7.00
13. Fermentation	4	10		6.20
14. Bundling and classification		80		24.00
15. Incidentals				10.00

Total expenses	₱222.50	
Estimated yield, 20 quintales batek at ₱20 a quintal		₱400.00
Net profit if only batek is produced	177.50	
Additional yield, 8 quintales of cigar filler at ₱9 a quintal	72.00	
Net profit if sucker leaves are harvested as filler	249.50	
Additional yield of 4 quintales wrapper at ₱25 a quintal	100.00	
Net profit if in addition the sand leaves are harvested and cured as wrapper leaf tobacco	349.50	

TABLE 3.—*Cost of producing one hectare of shade-grown wrapper leaf tobacco*

1. Preparation and sowing of seedbeds	September and October
2. Transplanting season	November and December
3. Shading period	January and February
4. Harvesting season	February to May
5. Planting distances	80 cms. × 70 cms.
6. Number of plants to the hectare	17,750
7. Estimated yield per hectare	750 kilos.

Items of operations	Approximate cost
	Pesos
1. Seedbed and rearing of seedlings	8.00
2. Preparation of field	25.00
3. Transplanting	16.00
4. Cost of shading materials	200.00
5. Erecting shed tent	40.00
6. Worming	20.00
7. Cultivation	15.00
8. Priming and poling	80.00
9. Curing and fermentation	15.00
10. Classification and bundling	100.00
11. Baling and baling materials	25.00
12. Depreciation of curing barn	60.00
13. Miscellaneous expenses	100.00
Total expenditure per hectare	704.00

Approximate yield per hectare:

200 kilos at ₱3 a kilo	₱600.00
200 kilos at ₱2 a kilo	400.00
100 kilos at ₱1.50 a kilo	150.00
100 kilos at ₱1 a kilo	100.00
150 kilos at ₱0.50 a kilo	75.00
Total gross income	1,325.00
Total expenditure	704.00
Net income per hectare	621.00

ILLUSTRATIONS

PLATE 1

FIG. 1. A good stand of Simmaba tobacco seedlings 45 days old almost ready for transplanting.
2. Typical tobacco curing barns for cigar filler, cigar wrapper, and batek types of tobacco.

PLATE 2

FIG. 1. A typical plant of the Simmaba variety.
2. A typical plant of the Vizcaya variety.
3. Typical leaves of the Simmaba variety.
4. Typical leaves of the Vizcaya variety.

PLATE 3

A good stand of cigar filler tobacco of the Simmaba variety. Note that the flower heads are already cut off and the sand leaves already harvested as wrapper.

PLATE 4

A good stand of batek tobacco with sand leaves already harvested as wrapper leaf tobacco.

PLATE 5

A shade-grown wrapper tobacco plantation of the Vizcaya variety with abacá cloth as shade.

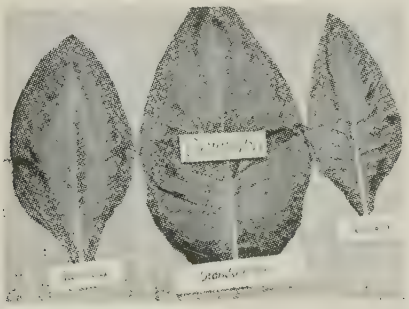
1

2

PLATE 1.

1

2



3

4

PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

A REPORT ON AN INSECT PEST OF WHITE AMARYLLI LILY IN THE TRINIDAD VALLEY, MOUNTAIN PROVINCE, PHILIPPINE ISLANDS [1]

By T. G. Fajardo and J. P. Tecson [2]

Of the Bureau of Plant Industry

NINE PLATES

INTRODUCTION

The white amarylli lily, *Crinum zeylanicum* Linn. is an ornamental plant which is cultivated in the vicinity of Baguio and in Trinidad Valley for its beautiful white flowers. In the Trinidad Agricultural School, this ornamental plant is more extensively grown bringing to this school a good yearly income from the sales of flowers and bulbs (Plate 1).

In November, 1933, a serious outbreak of an insect pest was noted at this school, causing considerable damage on the amarylli plants. The larvæ (Plate 7, figs. 1, 2, 3, and 4) attacked all parts of the plant, devouring the leaves, pseudostems, and the bulbs (Plates 2, 3, 4, and 5). Where the infestation was severe, the plants were destroyed within a few days. This pest was noted two or three years ago but it was then doing very insignificant damage as to warrant any measure to control it. It became very serious in 1933, and even at present, in spite of control measures practised by the school, this pest is still present.

Because this pest is very injurious, and has become established in this vicinity, a study of its life cycle, its food plants, and possible control measures was undertaken. The results are presented in this paper.

THE INSECT AND ITS NOMENCLATURE

Comparison of the moths reared in the laboratory and of those collected from the field revealed that the insect in question is

[1] Observation on this insect pest was started in 1933, but, because of other pressing problems its completion has been delayed. In May, 1936, the junior writer left this Bureau, and as the senior writer finds little time to carry the work further, this paper is prepared to present the salient facts thus far obtained.

[2] The writers are grateful to Dr. G. Merino and Mr. F. Q. Otanes, of the Plant Pest and Disease Control Division for kindly reading and criticizing the manuscript.

identical to the species *Glottula dominica* Cramer,[3] specimens of which were collected from Manila in 1912 by Schultze (Plates 6 and 7). Furthermore, the insect in question conforms with the description by various authors (1) (2) of the adult and larvæ of *G. dominica* Cramer. According to Moore (2) the technical description of this species is as follows:

Adult: "Forewing dark grayish violacious brown; discal area suffused with ochreous, and with a transverse submarginal slightly ferruginous bordered ochreous denticulated line. Across the middle are two black greyish bordered sinous lines with more or less acute greyish points on the veins, orbicular spot very indistinct; reniform spot pale, indistinctly formed with ferruginous and black streaked center; a marginal grey bordered black denticulated line; hind wing cinereous-white in male, slightly brownish along anterior border, and brownish externally in female. Thorax, head, and legs dark greyish violaceous-brown, abdomen dark cinereous-brown. Expanse, male, 1.2, female, 1.5 inch.

Larvæ: "Larvæ thick, warty, second to eleventh segment black, spotted with bluish-white; head, top of second segment, and the two anal segments red, with black spot; legs red; forelegs black tipped. Pupa purplish brown. Feeds on Amaryllis."

DISTRIBUTION OF *G. DOMINICA* CRAMER

According to Hampson (1), *G. dominica* Cramer is known to occur in South Africa, Mauritius, throughout continental India, Ceylon, and Burma. In the Philippines, Schultze collected *G. dominica* Cramer in 1912 in Manila, and in 1933, it was noted doing considerable damage at the Trinidad Agricultural School. In a survey made, it has still a limited distribution and has been found only at this school.

INJURY AND ECONOMIC IMPORTANCE

The larvæ feed voraciously on all the juicy, tender, and succulent parts of the plant. The very young larvæ have a very characteristic feeding habit. They bore into the succulent leaves and feed in the tissues in groups or form columns in one direction, leaving the thin papery epidermal tissues uneaten, thus affording them protection while developing (Plate 4). These larvaæ may remain in this condition as "leafminers" until after about the 4th instar when they are much bigger. The older larvæ are more voracious feeders and devour the leaves (Plate 6), flower stalks, pseudostems, and even the bulbs (Plates 2, 3,

[3] The writers are grateful to Mr. G. Bellosillo, Assistant Entomologist, for comparing the adult moth reared in the laboratory with the Bureau of Science Museum specimens of *Glottula dominica* Cramer, of the family Noctuidæ, order Lepidoptera.

4, and 5). If the infestation is extensive, a full grown plant may be destroyed in a few days. The injury is most severe when the larvæ follow to feed in the inner tissues of the pseudostem, completely destroying the plant, or "setting it back," thus making it useless in so far as the production of flowers is concerned (Plate 3). The bulbs in the field or those kept in storage are also attacked, and if the injury is severe, the vigor or vitality of the plant resulting from an injured bulb is greatly reduced.

FOOD PLANTS

The larvæ, have a narrow range of host plants on which to feed. In feeding experiments conducted in the laboratory, the larvæ fed readily on the white amarylli lily, *C. zeylanicum* Linn. and on *C. chinensis* and less on *C. asiaticum* Linn. The other plants which were tried but not eaten, or slightly eaten only, are the spider lily, *Zantedeschia acthiopica* Spring *Hemenocallis littorale* (Jacq.) Salisb., the red amarylli lily, *Atamosco rosæ* (Lindl.) Greene, *Cordyline roxleurghiana* (Schultes) Merr. *Rheœ discolor* (L. Herit.) Hance, calla lily, and croccus lily (Table 1). In this connection field observation showed that these species were not readily attacked, even if planted in the adjoining field with the amarylli plants.

TABLE 1.—*Feeding trials in the laboratory of the larvæ of G. dominica* Cramer

Hosts[a]	Remarks
Crinum zeylanicum Linn.	Readily eaten and finished the leaves after 12 hours.
Crinum chinensis	Readily eaten and finished the leaves after 12 hours.
Crinum asiaticum Linn.	Less readily eaten and only small portion devoured after 12 hours.
Hymenocallis littorale (Jacq.) Salisb.	Not tasted after 6 hours and after 12 hours a small area was tasted.
Atamosco rosæ (Lindl.) Greene	Tasted but feeding was not continued.
Cordyline roxleurghiana (Schultes) Merr.	Not tasted even after 12 hours.
Rheœ discolor (L. Herit.) Hance	Do.
Zantendeschia acthiopica Spring. (Calla. Lily).	Do.
Hippeastrum sp. (Amaryllis)	Do.

[a] Plant specimens were kindly identified by Dr. Eduardo Quisumbing, Chief, National Museum Division, Bureau of Science.

DURATION OF LIFE CYCLE

The studies on the life history were conducted under laboratory conditions both in Manila and in Baguio. Unless otherwise

stated, the larvæ soon after hatching were reared in battery jars or in 1000 cc. beakers, the tops of which were covered with thin cheese cloth, and on the bottom about 2 inches of soil, or pieces of filter paper were placed for pupation. The larvæ were fed with leaves of *C. zeylanicum* Linn. or *C. chinensis*, while the moths were fed with cotton bolls moistened with sugar. The adults were separated or killed as soon as sufficient eggs were laid, and the other stages of life cycle were observed.

From Table 2, it will be seen that in Manila, the duration of life cycle from November to February averages from 32.5 to 34.75 days; while in Baguio, it averages from 53.25 to 61.75 days depending upon the time of the year when the experiments are conducted. It is interesting to note that in Manila when the studies were conducted from November to February, which are the cooler months of the year, the duration of life cycle was very much shorter than those conducted during the summer months in Baguio, and when the life cycle is conducted during the cooler months in the latter region, it is delayed to almost twice as long. In this connection, it was observed that the larvæ reared under Baguio conditions were somewhat bigger than those developed in Manila.

TABLE 2.—*Duration of life cycle of Glottula dominica* Cramer *under laboratory conditions in Manila and in Baguio*

Life stages	Duration of life stages in Manila (28–30°C)				Duration of life stages in Baguio (17–22°C)			
	November to December 1933		December 1933 to February 1934		February to March 1935		March to April 1935[a]	
	Min. days	Max. days	Min. days	Max. days	Min. days	Max. days	Min. days	Max. days
Egg stage	5.0	6.0	4.0	6.0	12.0	14.0	10.0	12.0
Larval stage:								
1st instar	2.0	2.0	1.5	2.0	3.0	3.5	3.0	4.0
2nd instar	2.0	2.5	2.0	2.0	3.0	3.5	3.0	3.5
3rd instar	2.0	2.5	1.5	2.0	4.0	4.5	3.0	3.5
4th instar	2.5	3.0	2.0	2.0	4.0	4.5	3.0	3.5
5th instar	2.0	3.0	2.5	3.0	5.0	5.5	4.0	5.0
6th instar	5.0	6.0	4.5	5.0	6.0	7.0	5.0	6.0
Pupal stage	8.0	10.0	9.0	10.0	18.0	20.0	15.0	17.0
Adult stage	1.0	5.0	1.0	5.0	1.0	5.0	1.0	5.0
Total	29.5	40.0	28.0	37.0	56.0	67.5	47.0	59.5
Average	34.75		32.5		61.75		53.25	

[a] Average from two series conducted simultaneously.

DESCRIPTION OF STAGES

In the above study, although differences were noted in the size and duration of life stages, little difference was observed in the characteristic markings of the different stages. For this purpose, the description of the stages are taken from one of the series conducted in Manila as follows:

I. THE EGG STAGE

The eggs are 0.6 to 0.7 mm. in diameter. In the laboratory, they were laid singly or in groups in irregular masses on the sides of the container, or on pieces of paper when present, while in the field, they are generally laid irregularly on the surface of the leaves. When viewed from above, they are circular, but from the side they are elliptical and slightly flattened on the side of attachment. When newly laid, the eggs are bright yellow, but later become light colored with a black dot on the region of the micropyle which indicates the head of the young embryo larva. When the egg hatches, the larva comes out first by its head and frees itself by wiggling.

II. THE LARVAL STAGES

First instar.—The first instar larvæ soon after hatching are weak and move very little. They are from 1.5 to 2.5 mm. long by 0.3 to 0.5 mm. wide. Later on, they seek their food, bore and feed in the leaf tissues between the epidermal layers. The head is prominent, brown, with two brown eyes. The body is whitish-brown with short fine hairs, but later it becomes yellowish-brown. After a day, the head becomes shiny, brownish-black, almost as wide as the body. The prothorax is yellowish-brown; prolegs brown; abdomen yellowish-green becoming lighter at the posterior end; the last two posterior segments brown; body dirty white with yellow tinge.

Second instar.—The larvæ are from 4.0 to 6.0 mm. long and 0.7 to 0.8 mm. wide. They are yellowish brown with brown bands around the body. The head, with two black eyes is yellowish brown to reddish-brown, with two small black dots on the dorsal side of the head and another pair on the yellowish-brown prothorax. The body is reddish-brown with creamy white spots around the body segments from the 2nd to the 11th segment. The prolegs are dark brown, and abdominal legs and anal segments yellowish-brown with dark brown band.

Third instar.—The larvæ are from 5.0 to 7.0 mm. long by 0.8 to 1.0 mm. wide. At first they are yellowish-brown but later become generally brownish-black. The head and prothorax are reddish-brown, with four black dots on the dorsal side and another pair on the lateral side with hairs; the bluish-white spots on the body are much enlarged. The body hairs are longer and darker. The true legs are black, the false legs yellowish-brown with a dark-brown band. The two anal segments are yellowish-brown with black areas on the dorsal part.

Fourth instar.—The larvæ are from 13.0 to 14.5 mm. long by 2.0 to 2.5 mm. wide. They are cylindrical, thick, brownish-black with the black color alternated with the bluish-white spots from the 2nd to the 11th segment. The head and prothorax have the same characteristics as the 3rd instar. The posterior end tapers a little and is reddish-brown marked by four dots. They feed voraciously and increase in size rapidly. At this stage, they lose their tunnelling habit.

Fifth instar.—The larvæ are from 22.0 to 25.0 mm. long by 4.0 to 6.0 mm. wide, and have identical markings as the 4th instar larvæ. They are at first yellowish-brown, but later become brownish-black with more distinct bluish spots. The head and prothorax are reddish-brown, antennæ yellowish-brown; the true legs black; the false legs yellowish-brown with a dark-brown band. The body is dark-brown, with bluish spots alternated from the 2nd to the 11th segments; hairs sparse; the posterior end reddish-brown at the base with a dark band.

Sixth instar.—The larvæ are from 27.0 to 35.0 mm. long by 4.0 to 6.0 mm. wide, and are identical to the 5th instar larvæ. They are at first yellowish-brown, but later become brownish-black. They feed voraciously and increase in size rapidly and become more bulky and warty. The full-grown larvæ are from 36.0 to 50.0 mm. long by 6.5 to 8.0 mm. wide. When about to pupate, the larvæ refuse to eat, or eat only sparingly. They are sluggish, contract, bury, and build an earthern cell. They may pupate without encasement or they may use only filter papers. In the field, however, they may pupate in the ground.

III. THE PUPAL STAGE

The pupæ are generally cylindrical, segmented, and abruptly tapered at the posterior end. They are at first yellowish-brown, but later become purplish-brown. They are from 20.0 to 30.0 mm. long and 7.0 to 8.0 mm. wide. Before the adult emerges, the joints of the pupæ are stretched, and the head comes out

by breaking through the posterior end. By continuous wiggling, the adult soon frees itself from the pupal case.

IV. ADULT STAGE

After emergence, the moth is weak, but a few hours later, it can move or walk or fly. After a day, the female begins to lay eggs and may lay as many as 500 eggs during its life period which is from 3 to 6 days depending upon certain conditions. Copulation, and oviposition generally take place at night.

The adult female is grayish-black and is generally larger than the male. It is 17.0 to 19.0 mm. from the head to the posterior end of the abdomen and 5.5 to 6.0 mm. wide on the thorax. The head is fair in size; covered with black hairs; possesses a pair of gray eyes and two prominent reddish antennæ. The thorax and legs are covered with numerous dark grayish-brown hairs; abdomen grayish-black. The forewing expanse is from 40.0 to 44.0 mm., dark grayish-violet-brown, the central portion obscured. On the margin is a gray black denticulated line. The hind wing has distinct venations, brownish-black along the borders and lighter in color about the base.

The adult male is smaller than the female and measures from 14.0 to 17.0 mm. from the head to the posterior end of the abdomen, and 4.5 to 5.0 mm. wide on the thorax. The forewing expanse is 36.0 to 38.0 mm. In general, the male is similar to the female, except that the hindwing is lighter with dark-brown shades on the apical end.

EXPERIMENTS ON CONTROL METHODS

Control by chemical methods.—In a series of experiments, lead arsenate, dry Bordeaux mixture, dry lime sulfur, and sulfur flower were applied either by dusting on the larvæ or by feeding the larvæ with the leaves dusted with the poison. The larvæ were then confined in mason jars or in 1,000 cc. beaker, the top of which were covered with cheese cloth, and after 24 hours, the percentage of kill was determined. The results which are summarized in Table 4 show that lead arsenate powder applied on the leaves, or dry fungi Bordeaux and dry lime sulfur applied on the larvæ killed all the larvæ after 24 hours, while flower of sulfur dusted on the larvæ, or dry Bordeaux or lime sulfur dusted on the leaves did not have any effect at all. The check larvæ, which were not treated with any poison were still alive after 96 hours.

In another series, 0.2, 0.5, 1, 2, and 5 per cent solutions of lead arsenate were thoroughly sprayed each on 1 foot of amarylli leaf, and then 5 larvæ reared from the laboratory were allowed to feed on each leaf and put into separate containers. After 2 hours, those fed on leaves sprayed with 0.2, 0.5 or 1 per cent were still alive and continued to feed, while those fed on 2 and 5 per cent became sluggish and ate only a small portion of the leaf. After 22 hours, the leaf sprayed with 0.2 per cent solution was all eaten but only one of the larvæ died; the leaf sprayed with 0.5 per cent was not all eaten but 2 larvæ died; while the leaves sprayed with 1, 2, and 5 per cent were each eaten in a small area, but all the larvæ were killed. The check, in which the same age larvæ were fed with unpoisoned leaves, continued to live and feed vigorously until the end of the experiment.

TABLE 3.—*Studies on chemical control of G. dominica* Cramer

Chemicals used	Methods of application	Number of larvæ treated	Number of larvæ dead after 24 hours
Series I			
Lead arsenate	Leaf dusted [a]	10	10
Dry Fungi Bordeaux	do	5	0
Dry lime sulphur	do	5	0
Sulfur flower	Worms dusted	10	0
Dry Fungi Bordeaux	do	10	10
Dry lime sulphur	do	10	10
Check	No treatment	10	0
Series II [b]			
Lead arsenate:			
0.2% solution	Leaf sprayed	5	1
0.5% solution	do	5	2
1.0% solution	do	5	5
2.0% solution	do	5	5
5.0% solution	do	5	5

[a] The larvæ were allowed to feed on the leaves dusted with the poison.

[b] Leaves were sprayed with the corresponding lead arsenate solutions and then allowed the larvæ to feed.

Control by an insect parasite.—The egg parasite, *Trichogramma minutum*, is a potential parasite on the egg of *G. dominica* Cramer. In a series of experiments conducted in the laboratory in Baguio, several adults of this beneficial insect were liberated in a test tube containing 30 eggs of *G. dominica* Cramer reared in the laboratory. As check, another test tube with 20 eggs was used but no parasite was liberated. After 20 days, the eggs where *T. minutum* was liberated failed to hatch, while the

check gave a high percentage of hatch after 12 to 15 days. In this connection, a set of liberation of this useful insect was undertaken in the field, but, because of the drastic cutting of leaves and digging up of plants as a means of control practised by the Trinidad Agricultural School, *T. minutum* did not have much chance to get well established.

Control by an entomogenous fungus.—In limited inoculation experiments and observations in the field, a species of an entomogenous fungus was found responsible for the death of certain number of larvæ in the field. This is especially true during the moister months of the year when the fungus becomes very prevalent. These parasitized larvæ usually first become sluggish, pale or yellowish, and later die, and from these dead larvæ, whitish aerial mycelia, and greenish masses of pulverulent spores are abundantly produced (Plate 7, figs. 5, 6, 7, and 8).

TABLE 4.—*Natural field infection of larvæ of G. dominica* Cramer *by an entomogenous fungus (Collected August 9, 1934)*

Number of cultures	Number of dead larvæ and date of observation							Larvæ pupated Aug. 18
	Aug. 11	Aug. 13	Aug. 14	Aug. 15	Aug. 16	Aug. 17	Aug. 18	
Culture 1:								
10 larvæ	1		2					[a] 7
Culture 2:								
10 larvæ			2	2				[a] 6
Culture 3:								
12 larvæ		2			1	3		[b] 6
Culture 4:								
20 larvæ		1		2			2	[c] 15

[a] On September 9, 1934, the pupæ were moldly-attacked by the entomogenous fungus—and none emerged.

[b] Only one emerged and the other rotted and moldy.

[c] On September 10 only 3 emerged (male) and the rest rotted and moldy.

In order to obtain information on the number of larvæ becoming naturally infected in the field, 52 medium-sized larvæ were collected in the Trinidad Agricultural School on August 9, 1934, and were brought to Manila for observation. The larvæ were divided into 4 lots and each lot placed in a separate container. The larvæ were fed with *C. chinensis* obtained from Manila. As shown in Table 4, the larvæ began to die after a few days and out of 52 larvæ observed, 18 died during the larval stage, a few died during pupation period, and the others pupated normally and emerged into adult moths. From these dead larvæ

and the pupæ which failed to emerge, there developed the characteristic fungus growth when placed in a moist petri dish and incubated at 28°–32° C, or left at room temperature. In another series, collections were made in January, but at this time observations were made in Baguio. Infected larvæ were again noted, but the percentage of infection was low.

In addition to this observation, inoculations were made on laboratory-reared healthy larvæ with spores,[4] produced from the dead larvæ obtained from the field. The larvæ after inoculation were then placed in separate containers and fed with leaves of *C. zeylanicum* Linn. and *C. chinensis*.

In one set of experiments, one healthy larva was inoculated on November 23, 1934, by brushing the spores on the central ventral, on the dorsal part, on the dorsal side, and on the ventral side. Simultaneously with this experiment, four larvæ were inoculated by allowing them to feed on a piece of leaf dusted or sprayed with the fungus spores. As check, one larva of the same age was used, but the spores were not applied. With this series, the larva inoculated by brushing the spores on the dorsal side died after 6 days. The larva inoculated by brushing the spores on the central ventral part, or that one allowed to feed on the leaf inoculated by spraying, pupated incompletely and died. The larva inoculated by brushing the ventral side pupated, but died in the pupal stage. The larva inoculated on the dorsal side remained healthy and pupated normally as did the check. All these dead ones when placed in petri dishes and incubated at 28° 32° C. became covered with the mycelia of the fungus from which the typical greenish white masses of spores were produced. In another series, identical results were obtained in which two larvæ were immersed in a suspension of spores, with the death of the larvæ occurring within a few days. In this experiment the check larva which was only immersed in water pupated normally and emerged into a healthy adult female. From this limited observation and inoculation experiment, this fungus is undoubtedly pathogenic, and caused the death of certain number of the larvæ in the field under field conditions.

Control by other measures.—With the appearance of this pest in 1933 various methods of control have been tried at the Tri-

[4] This fungus has been cultured on artificial media, but failed to sporulate abundantly with the various media tried. So far no attempt has been made to determine its taxonomy.

nidad Agricultural School. Among those which were tried and proved very practical are: (*a*) cutting off and burying the infected leaves one-half meter deep; (*b*) cutting and burning infected leaves; (*c*) hand picking of worms or cutting infected leaves and crushing the worms; (*d*) digging up of the infested plants, removing all the leaves and then transplanting them into another field far from the infested plot; and (*e*) attracting the moth at night with torches.

From the results of these studies, the larvæ can be controlled by various means. Lead arsenate in powder form or in solution of 0.5 to 1 per cent or more applied on the leaves at the proper time is less expensive. The various other control measures, such as digging up of the plants, cutting of infected leaves and burying or burning them, and picking and crushing the larvæ are very practical and satisfactory, but these are tedious, very expensive, and rather harmful in view of the fact that by continuous digging and transplanting of the plants or cutting of the leaves, the plants are generally "set back" or stunted in growth (Plate 9). The control by means of the egg parasite, *T. minutum,* or by a species of an entomogenous fungus was shown to kill the eggs and larvæ, respectively.

SUMMARY

1. An insect pest, *Glottula dominica* Cramer, is reported serious on amarylli lily, *Crinum zeylanicum* Linn., in Trinidad Valley, Mountain Province.

2. It was found affecting the amarylli plants in Trinidad Agricultural School.

3. The larvæ are voracious feeders, and devour the leaves, flower stalks, pseudostems, and even the bulbs. They feed more readily on *C. zeylanicum* Linn. and *C. chinensis.*

4. The duration of life cycle under laboratory conditions in Manila is shorter than in Baguio. In Manila it ranges from 28 to 40 days, while in Baguio it is from 47 to 67.5 days, depending upon the months of the year when the studies were made.

5. Various methods of control have been tried. Lead arsenate in powder form or in solution of 0.5 to 1.0 per cent or more is very effective, especially on the larger larvæ when they feed on the leaves.

6. Collecting the worms and cutting off the infected leaves and burying or burning them are also very effective.

7. The egg parasite, *T. minutum* and a species of an entomogenous fungus were found to attack the egg and the larvæ of *G. dominica* Cramer respectively.

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ILLUSTRATIONS

PLATE 1

Section of a field of amarylli lily *Crinum zeylanicum* Linn. at the Trinidad Agricultural School.

PLATE 2

Section of a field of amarylli lily *C. zeylanicum* Linn. infested in September with the larvæ of *G. dominica* Cramer. The field was severely infested and nearly every plant was attacked and destroyed, so that the sales of flowers from the school was reduced to nil.

PLATE 3

Amarylli lily plants, destroyed by the larvæ of *G. dominica* Cramer. The terminal shoot and other succulent tissues are attacked.

PLATE 4

Closer view of an amarylli plants attacked by the larvae of *G. dominica* Cramer. Note that in some of the leaves, the papery thin epidermis are not eaten (at x). Between these layers, may be found the very young larvæ which feed in the tissues in columns or in groups.

PLATE 5

Amarylli plants severely attacked by *G. dominica* Cramer. In fig. 1, the larvæ started to bore through or across the pseudostem, while in fig. 2, the young terminal shoot and the succulent tissues inside were almost eaten up. These plants are useless in so far as the production of flowers for the season is concerned.

PLATE 6

Feeding injury on the amarylli leaves by the larvæ of *G. dominica* Cramer. Fig. 1 is an old leaf eaten up by larvæ, and fig. 2, a succulent leaf eaten up by the larvæ.

PLATE 7

Full grown larvæ of *G. dominica* Cramer. Figs. 1, 2, 3, and 4 are healthy larvæ, while figs. 5, 6, 7, and 8 are attacked and killed by a species of an entomogenous fungus. From these parasitized larvæ, abundant greenish white spores are produced.

PLATE 8

G. dominica Cramer showing certain stages of the insect. Fig. 1, adult male; Fig. 2, adult female; Fig. 3, larva about to pupate; Figs. 4 and 5, pupæ; Fig. 6, eggs; Fig. 7, full grown larva.

PLATE 9

A section of amarylli field after general cleaning, collecting the worms, and cutting and burning of the leaves as means of control done. This field was previously severely infested by *G. dominica* Cramer.

PLATE 1.

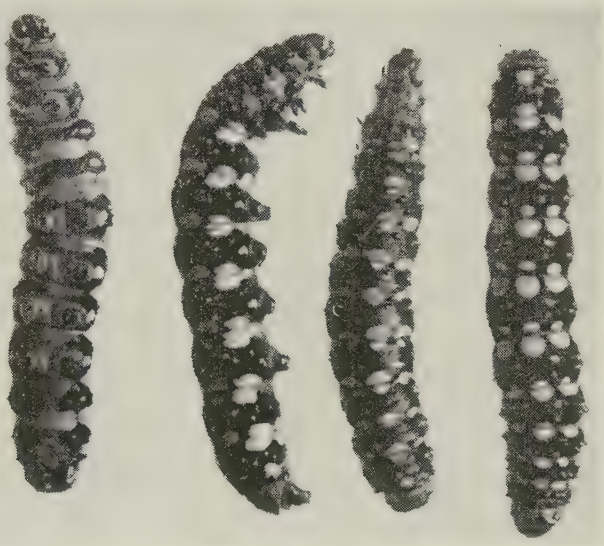
PLATE 2.

PLATE 3.

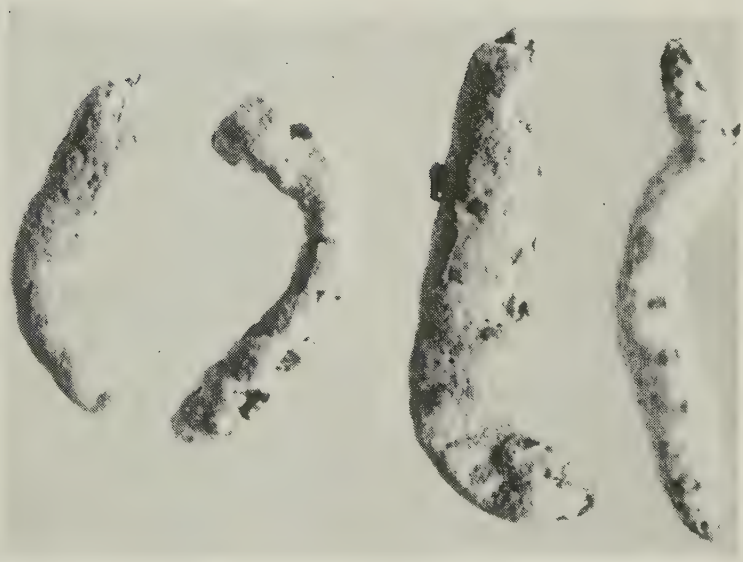
PLATE 4

PLATE I

PLATE 6.



1 2 3 4



5 6 7 8

PLATE 7.

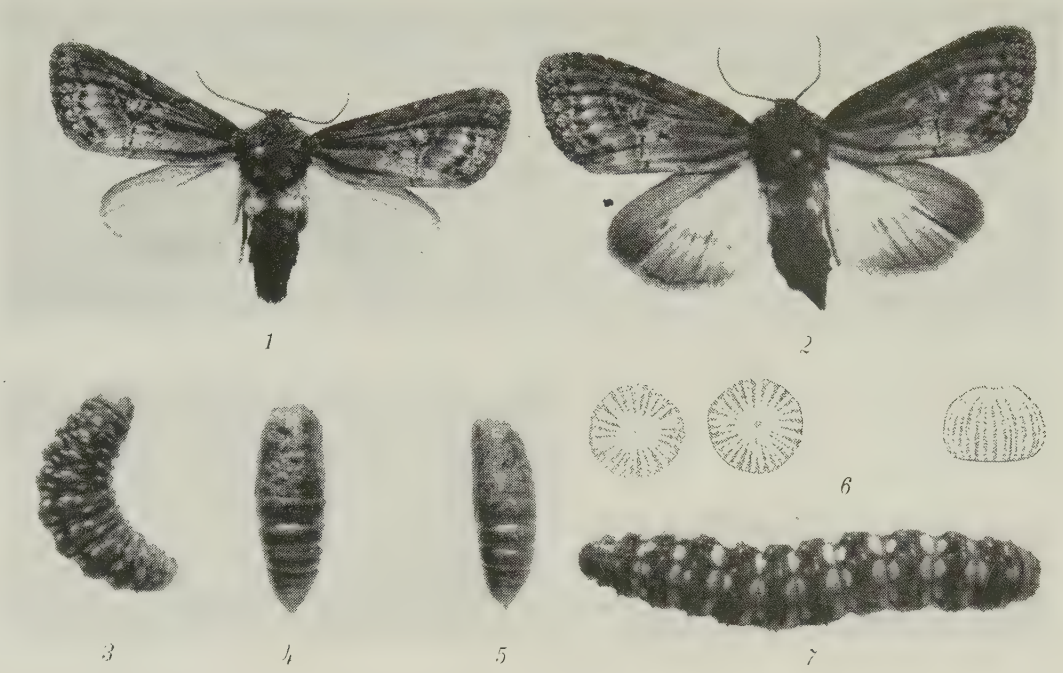


PLATE 8.

PLATE 9.

FARMERS' CIRCULAR SECTION

THE LANZON (*LANSIUM DOMESTICUM*, JACK)

(Farmers' Circular 6)

By ADRIANO M. ORGAS
Assistant Agronomist

TWO PLATES

The lanzon is known in the Philippines under many different names: *Lansones* (Tagalog and Bicol), *budhaw, boboa, bukan. buluhan* (Bisaya); *buahan* (Mbo., Sul.); *buan, malibongan, kalibungan* (Mbo.); *tubua* (Bag.); *bogko* (Bukidnon). In other places, it is called *langsat, langsep,* and *rambai.* In Malaya it is called *lanseh* or *lansa.* It is known in science as *Lansium domesticum* Jack, family *Meliaceæ.* Lanzon is one of the most wholesome and delicious fruits of this country. About one-half of the number of trees under cultivation is found in Laguna. The main lanzon regions in this country are located in the humid belts of the provinces of Laguna, Bukidnon, Albay, Tayabas, Samar, Mindoro, Oriental Misamis, Zamboanga, Davao, Lanao, Leyte, Sulu, Batangas, etc. However, in other parts of the Philippines like Bulacan, Pampanga, Iloilo, Cebu, and Manila, where the underground water is shallow, the lanzon is also grown with a fairly good success.

VARIETIES

Variations in the so-called varieties or types, for which six types of lanzon have been described by Mendiola, are distinguished by the shape of the fruits, size of the seeds, amount of milky juice in the flesh rind, and the sweetness or sourness of the fruits. It is said that the *duku* is a distinct variety of lanzon which is larger than the Philippine lanzon and is grown extensively in Malaya and Java. As in the Philippines, the lanzon grows wild in Java where three varieties are known; namely, *daeke, bigjitan,* and *kokosan.*

As to shape of fruits, two so-called varieties are recognized in the Philippines. These are the round and the elongated. The elongated is generally, if not always, a sweet variety.

Sweetness also is usually indicated by a blackish and purplish area at the base of the fruit around the stem. Lanzon fruits from trees grown in Paete and San Pablo, Laguna, are well known for their sweetness.

SOIL AND CLIMATIC REQUIREMENTS

Lanzon thrives best in districts where there is a uniform distribution of rainfall and in places where dry and wet seasons are distinct, and where the ground water is shallow, like that in Angeles, Pampanga. A site comparatively exempt from typhoons and strong winds, from sea level to about 2,000 feet elevation, and where the soil is loamy and well drained, is an ideal place for lanzon growing. Strong winds are bad especially when the trees are laden with flowers and fruits. In Paete, Laguna, where sweet bearing lanzon trees are found, the soil is clay loam admixed with boulders, with natural irrigation, but well drained due to the topography of the land.

PROPAGATION

Lanzon is either propagated by seed or vegetatively by grafting, marcotting, and budding. Before the vegetative methods of propagation, such as grafting and marcotting came to be used, propagating by seed was the only means employed by the growers, but trees propagated by this means take too long a time before bearing. Trees grown from seedlings are said to come into bearing in 12 to 20 years from the time of planting. The importance of vegetative methods of propagation of lanzon cannot, therefore, be overemphasized, since plants propagated vegetatively usually come into bearing earlier than seedling trees, and moreover, the quality of fruit is assured.

By seed.—The seeds are cleaned of any adhering flesh by washing them with fresh water. Then they are air-dried for some time before planting. This treatment is necessary in order not to allow adhering flesh to ferment and get moldy or otherwise attract ants to the sugary flesh of the seeds. The seeds should first be planted closely in seedbed and covered with soil about 1 centimeter deep. The seedbeds should be under partial shade. As a rule the seeds will germinate in from one to three weeks. When the seeds have completely germinated and the seedlings are about six inches high and have at least two

pairs of leaves, they should be pricked in nursery beds, spacing them 40 to 50 centimeters apart. In this way, they should be allowed to grow from 1½ to 2½ years and then they can be set out in the fields. The seedlings can also be planted in bamboo tubes when they are about a month old, and shipped to distant places with little possibility of injury in transit.

By grafting.—This is the best way of propagating lanzon, and is done by cleft grafting, using terminal, well matured, and non-petioled scion of the same age as the stock. The scion should be about 1 centimeter in diameter or about the size of a lead pencil and 6–10 centimeters long containing at least 3 or 4 buds. Usually, in case of freshly cut scions, they are first furred in seedbeds mostly sandy in nature and allowed to remain there for a month or so until buds have protruded about 4 to 6 millimeters, when they are then ready for insertion. These scions should be grafted on when they are at the point of callousing, fresh and sound ones being selected. Grafting should be done during the wet season. The trunk of the stock should have a diameter of the size of a lead pencil also or a bit bigger than the scion. Lanzon seedlings are ready for grafting at the age of from 2½ to 3½ years. Grafted plants begin to bear in 7 years from planting in the permanent field.

By marcotting.—Marcotting is one of the oldest methods of vegetative propagation and has been used successfully with many trees including the lanzon. The Filipino fruit growers are familiar with it, especially in propagating chico. Marcotting is performed by ringing a branch or twig while it is attached to the parent plant, and then applying soil to the ringed section to induce root formation. Branches about 1½ to 2 inches in diameter are used for this purpose. "Cabo negro" fiber (*Arenga saccharifera*) or coconut husk is used for wrapping and holding the ball of soil around the girdled section. The soil should cover the girdled portion completely. Fine wire should be used for tying the "cabo negro" fiber or coconut husk to hold it in place and keep it compact, and to afford greater security. The marcotted branch should be watered as often as necessary. Rooting will take place in about two months after marcotting, and the marcots may be severed from the mother plant in 5 to 6 months when the secondary roots shall have matured, and penetrated through the wrappings. Care must be exercised not to

marcot too many branches on one tree. Unlike the chico, lanzon is a delicate tree. On a commercial basis, this method is impractical as it would need many trees to do the marcotting on. The best time to marcot is at the beginning of the rainy season. Some marcotted plants come into bearing at the second year.

By cutting.—Propagation by cutting may be used with the lanzon. This recommendation is made only to experienced nurserymen. Over 50 per cent success could be attained under ideal conditions. This method may be described as follows: Beds with a depth of 25 centimeters and at convenient length are prepared under the shade of trees by digging out a considerable portion of the soil and then replacing it with enough medium-coarse, fresh-water sand. The sand may be leveled and packed firmly with a spade. Fairly well matured wood should be used for cuttings. With pruning shears, the branches should be trimmed off close to the stem and both ends cut slantingly with a sharp knife taking care not to bruise the wood. The cuttings should be placed in porcelain jars having a capacity of 1,000 cc. Two hundred cubic centimeters of 1.5 to 2 per cent potassium permanganate solution should be poured into each jar, immersing about 2 centimeters of the basal ends of the cuttings in the solution. After about 24 hours of immersion the cuttings are set in the beds. The ends of the cuttings should not be bruised. Then the cuttings are placed in the holes about $\frac{2}{3}$ of their length, in a slanting position. To keep them in position, the sand is pressed gently around the cuttings. The cuttings may be transplanted directly to the nursery rows after they have made a well established root system in the beds, which may be made four months after setting.

PREPARATION OF LAND AND PLANTING

When a forest land is used, the general practice is to cut down the trees and burn them as they become dry, leaving the stumps to decay. The land is then planted without first being plowed. The land should be planted with cover crop so as to check the growth of weeds.

Shade trees.—The lanzon plant needs a little shade for its proper development. For this reason such shade trees as madrecacao and ipil-ipil may be used during the early stage of their

growth and later thinned so as not to interfere with the full development of the branches of the lanzon. For purposes of dual farm income avocado and breadfruit may also be planted as shade trees. Temporary shade trees may be planted during the early life of the plantation until the permanent shade trees have been established. In Paete, Laguna, santol trees are used as shade, thereby having two crop plants on the same piece of land. It has been found, however, that shaded trees give not a little more yield than unshaded trees.

Planting.—Seedlings when about two to three years old or vegetatively propagated plants are generally set out in the field at least 7 by 7 meters apart. The size and depth of the holes in which to plant the seedlings will depend upon the size of the seedlings, the kind of soil, and the size of the bolled earth around the root system. The plants should not be planted deeper in the field than they were in the nursery.

CARE AND CULTIVATION OF PLANTATION

Cultivation in the form of ring weeding and shallow hoeing around the plant to a radius of at least one meter should be done at least 2 times a year during the early life of the lanzon plants. The plants should be mulched during the dry season in order to conserve the moisture of the soil.

PRUNING

Judicious pruning should be practised from the time the lanzon trees are about 4 or 5 years old to get a fine formation of trunk and branches. Sharp pruning tools should be used, and cuts or wounded parts should be painted with white lead or coal tar. Pruning should be done only during the dry season.

HARVESTING

The fruit ripens in about 5 to 6 months from the time of flowering which takes place in June, particularly under Laguna conditions. In picking, the matured fruit should never be pulled off as to injure that portion in which the bunch is attached because it is within this region where the second "set" of fruit

develops. A sharp knife or shears should be used in clipping off the bunches. The fruit should not be picked before it is fully matured.

Seedling trees 30 years old yield a little over 1 "kaing," while trees 55 years old yield about 3 "kaings" on the average. A "kaing" of lanzon contains about 1,500 to 2,500 fruits.

The supply of lanzon fruits is most abundant in Luzon from the middle of September up to October and in Mindanao from January to February.

PESTS AND DISEASES

Lanzon trees are troubled by "dapu" (*Loranthus*) and some caterpillars and mites that feed in the bark. Lichens are also troublesome if abundant. Root disease also attacks both young and old trees.

"Dapu" (Loranthus).—This is a parasite that is found growing on the lanzon plant. It attaches itself to the plant by means of its small projections which absorb water and other food substances from the host plant. This parasite produces sticky seeds which the birds may disseminate among the trees by rubbing them off their beaks on the bark. This can be controlled by simply cutting off the affected twigs and burning them.

Caterpillars and mites.—To control these pests, scrape or clean the affected parts and apply concentrated lime sulphur or lime sulphur sludge. The lime sulphur may also be used against the lichens as a spray.

Root Disease.—This disease attacks both the young and old trees, but the older ones succumb more easily to the malady.

Externally, the early stage of the disease on the above-ground parts of the plants in the field is characterized by the yellowing and wilting of the leaf and the gradual falling off of the younger leaves and then of the older ones. The petiole easily breaks off.

In the soil the disease travels from the small lateral roots toward the bigger ones and then to the base of the stem causing a gradual decay. The roots rot and usually are distinctly brownish black in parts, but in severe cases the marked absence of roots as a result of the disease is especially noticeable. This naturally results in the death of the plant from lack of food and water.

In the advanced stage of the disease all the roots decay up to the base of the stem, and then comes the death of the tree. Where the infection is severe all the leaves wilt very quickly, yet persist on the plant for a number of days or even weeks. Later the tree is defoliated. The roots, trunk, and branches gradually dry up. A wet, white, cottony mycelium, visible to the naked eyes, penetrates the wood and disintegrates the tissues of the decayed roots, which easily break off and look very different from the healthy portions.

The disease may be controlled by the following methods:

1. Destroying all diseased materials, such as stumps and rotten logs and burning them.
2. Cutting off the affected lateral roots as well as that portion of the top root which shows the presence of fungus.
3. Applying unslaked lime in 2 or 3 feet deep trench around the diseased tree, after washing the affected portions with a four per cent formalin solution, the idea being to isolate affected trees from the healthy ones.
4. Employing good cultural practices, such as proper cultivation, drainage, sanitation, etc.

CHEMICAL CONSTITUENTS OF RIND, SEED, ETC.

The flesh of the fruit contains 1.13 per cent protein, 13.00 per cent sugar and 0.59 per cent ash. It is believed that the rind and seed contain some chemical constituents which are medicinally and industrially important. The outer skin is bitter and is regarded as very rich in tannin. No definite use for the seed and the rind has been satisfactorily found so far. However, the peninsular Malays use the juice of *langsat* for treating sore eyes, the decoction of its bark and leaves for treating dysentery, and the powdered bark as a remedy for scorpion stings. In our country, generally the rind is dried and burned inside the house for the purpose of driving away mosquitoes by means of the smoke; it is given preference over other remedies because of the pleasant odor emitted on burning. It is said that the inhalation of the smoke of the rind has a soothing effect on tuberculous persons, and a decoction of the branches is sometimes used as a stomachic.

FARM MANAGEMENT

(a) Estimated cost of bringing into bearing one hectare of lanzon plantation

Items of operation	Man	Approximate cost
	Day	*Pesos*
First year:		
1. Cost of 204 lanzon seedlings at ₱0.10 each		20.40
2. Cleaning the jungle	75	75.00
3. Burning the debris	6	6.00
4. Staking	4	4.00
5. Planting shade trees (both temporary and permanent)	6	6.00
6. Cost of seeds of shade trees		2.00
7. Digging holes (204 at 7 x 7 m.)	20	20.00
8. Distributing the seedlings in the field	1	1.00
9. Planting seedlings in permanent field	4	4.00
10. Weeding with hoe (2 times during the rest of the year)	16	16.00
11. Replanting, materials and labor	1	3.00
Total expenses for the first year		157.40
Second year:		
1. Replanting, materials and labor	1	2.00
2. Ring weeding (4 times)	12	12.00
3. Thinning shade trees and mulching	6	6.00
Total expenses for the second year		20.00
Third year:		
Same expenses as for the second year		20.00
Fourth year:		
Same expenses as for the second year		20.00
Fifth year:		
1. Ring weeding (4 times)	12	12.00
2. Trimming the temporary and permanent shade trees	8	8.00
3. Pruning the lanzon trees	10	10.00
Total expenses for the fifth year		30.00

The average annual maintenance expenses for pruning of the plants, trimming the shade trees, cultivation, treatment of diseases, and mulching is estimated to be ₱25 to ₱30 from the 6th to the 12th year.

The total expenses for planting and bringing into bearing one hectare of lanzon plantation is ₱457.40.

The expenses in the maintenance of the lanzon plantation up to the bearing stage may be reduced by planting bananas which should be thinned out as fast as they come to interfere with the development of the lanzon plants.

If grafted and marcotted plants are to be used for planting the cost of planting materials will vary according to the cost of grafted and marcotted plants. Grafted plants cost ₱1 each, and marcotted plants cost about ₱5 each. The plantation is expected to bear much earlier, however.

(b) Cost of production per hectare at full bearing—204 trees

Items of operation	Man	Approximate cost
	Day	*Pesos*
1. Maintenance expenses for pruning, treatment of diseases and general care	35	35.00
2. Interest on value of land (6% of ₱500.00)		30.00
3. Land tax		4.38
4. Picking 200 "kaings" of lanzon fruits	20	20.00
5. Collecting the fruits	5	5.00
6. Putting the fruits in "kaings"	2	2.00
7. Cost of "kaings" (200)		100.00
Total expenses		196.38
Value of 200 "kaings" of lanzon at ₱5 per "kaing"		1,000.00
Net profit		803.62

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ILLUSTRATIONS

PLATE 1.

PLATE 2.

THE CULTURE OF DERRIS

(Farmers' Circular 7—Revised)

By JUAN M. EJERCITO

Assistant Agronomist

Derris is widely distributed in the Philippines. Its use as poison for fish has been well known to the inhabitants of the Islands as well as those of the Malayan Peninsula and the East Indies, probably since prehistoric times.

Not very long ago, scientists discovered the efficient use of *Derris* roots against many kinds of insects injurious to both plants and animals. Being non-poisonous to men but very effective against insects, insecticide preparations from *Derris* roots are now preferred to calcium arsenate which has heretofore been used extensively for exterminating plant pests. At no time in the history of scientific agriculture is the demand for and the use of *Derris* greater and more extensive than now.

Insecticides worth many millions of pesos are consumed annually in the United States, Japan, and other countries. The entire crop loss caused by injurious insects in the United States alone is conservatively estimated at 4,000,000,000 pesos annually. And that country yearly consumes about 14,000,000,000 kilos of calcium and lead arsenate, and 5,000,000,000 kilos of pyrethrum valued at ₱5,325,000,000, which insecticides can be substituted by *Derris* root insecticide. The United States then, besides Japan and Europe, is one of the big markets for *Derris*. Starting in 1931, the United States imported *Derris* roots to the amount of 2,049 kilos valued at ₱940, and in 1934, this importation rose up to 203,503 kilos valued at ₱139,674. Various inquiries from different chemical laboratories in the United States have been received by the Bureau of Plant Industry regarding the possibility of obtaining *Derris* roots from the Philippines. The extensive cultivation of this plant here will undoubtedly be another source of income for the farmers.

As an insecticide, *Derris* has been found efficient, both as a stomach and as a contact poison and sometimes acts as a repel-

lant to many cold-blooded animals. It is applied either in solution or powder form. *Derris* powder applied as dust is efficient against dog fleas, cattle teak, bed bugs, chicken lice, house flies, white ants, some species of aphids, and certain vegetable pests. As spray, it is efficient against the larvæ of sawflies, imagoes and larvæ of leaf beetles, plant lice, cabbage worms, etc. *Derris* root compares favorably with any inorganic insecticide, since its application even to the youngest leaves and seedlings and on the roots of plants does not inflict any apparent damage thereon. There are many trade preparations of *Derris* now on the market, such as "Polvo" (a powder), "Kotakila" (powder and soap), "Derrisine" (a liquid), *Derris* ether extract, Derispray and Rotenone (90 per cent chemically pure).

Besides its value as a source of insecticides, *Derris*, being a leguminous plant, is capable of enriching the soil and, for this reason, it is worth trying as a cover crop. Most *Derris* species being creepers, form a close cover on the ground which may also serve as a remedy against soil erosion.

VARIETIES

There are 15 distinct identified species in the Islands that grow wild by the sides of creeks, rivers, and lakes, and in the forests. But only one or two have shown promise and are being brought into cultivation on a commercial scale, *Derris elliptica* and *D. sp.*, sometimes called by the new name of *D. tubli*. Their analysis shows from nil to about 10 per cent rotenone content, although 4 to 5 per cent is the average. These varieties are called under various names in different regions, such as "Tuble" in Batangas, Laguna, Cavite, Tayabas, and sometimes in northern Bicol; "Polipog" in Cebu, Bohol, Negros, southern Leyte, and northern Surigao; "Pamalanak" in northern Leyte and in Samar; "Labnec" in Cuyo Islands; "Balval" in Calamian group; "Tubali" in Manobo regions; "Lapak" in southern Bicol; "Tuba" in Panay Island; "Tua" in Cotabato; "Baot" in La Union; and "Kabutot" in Bontoc. These varieties have a prostrate habit, forming a close cover, with the stems rooting at the nodes if allowed to grow without any trellise. The number of leaflets varies from 7, 9, 11, 13 or 15 and are very variable in size and shape, but usually obovate or obovate oblong, the lower one or two pairs reduced in size and broader in proportion than the others.

IMPORTANT CONSIDERATIONS

As the value of *Derris* roots is based on the rotenone content and on the total ether extract, it is most important therefore, that prospective planters plant only the high yielding variety.

The rotenone content has been found to differ largely in different species of *Derris,* and analysis of roots of the same species and age grown in different localities in the same country may give different results. The optimum age in which to harvest so that the maximum rotenone content may be obtained may also differ in different regions. It is, therefore, very necessary that to obtain full information on these points, a fairly intensive study in the district in which any species is to be cultivated be made first. Equally important is the conscientious selection of the right planting materials. This can be determined by first analyzing the roots. If 4 or higher per cent of rotenone is obtained, stem cuttings from said plant should be immediately multiplied for commercial propagation.

PROPAGATION

Derris is propagated from seeds and by cuttings. But commercially it is readily grown by cuttings since it can be easily rooted. The cuttings are mature stem or vine with 2 to 4 nodes each and about 30 centimeters long. They are closely planted in the nursery beds. Any damp ravine adjoining the proposed field is the best site for a nursery. A layer of cogon or grass is preferably laid on the bed to keep the cuttings fresh and the soil moist. In about 3 weeks, the majority will sprout and in 2 to 3 weeks more, they can be transplanted in the field. Experience has shown that the cuttings may also be preserved in moist sphagnum moss for 3 weeks before planting direct in the field, after which time some roots come out. In another instance it was also observed that loosely bundled cuttings with the base stuck in the mud under shade produce roots in about 3 weeks. It has been generally observed that if the cuttings are planted direct in the field without the practise of any of said treatments, many die and in which case they should be replaced as early as possible by fresh cuttings so as to have an even and solid stand.

The cuttings are planted in a slanting position at an angle of about 45° with the surface of the ground, and with about $\frac{2}{3}$

of the length below the surface. They are planted at a distance of 1 meter, giving 10,000 plants per hectare. A closer spacing of 90 centimeters may be set in poor soil, giving 12,345 plants to the hectare. The field should be prepared similar to those for corn, peanut, etc. In Malaya, the cuttings are planted in big ridges of about ½ meter high with the aim of rendering the harvesting easy. On newly opened land where there are considerable timber and stumps, it is sufficient to make good sized holes in which to plant the cuttings.

Derris should be planted in a light soil of a sandy nature. Heavy clay soils are not recommended, owing to the difficulty in harvesting the roots under such conditions. The land may be flat or gently undulating.

The best time to plant is at the start of the rainy season. Plowing between the rows during the early stage of the plants and occasional hand weeding in the rows constitute the care that should be given the plants. In their later stage, the plants almost cover the ground and only few weeds are able to survive. It has been observed, however, that derris plants grow profusely under partial shade or under humid conditions—places similar to their natural habitat.

Derris may be cultivated between rows of other crops, such as young coconut, young abacá, kapok, rubber, citrus, etc.

HARVESTING AND PREPARATION FOR THE MARKET

As the toxicity of *Derris* roots varies according to their age, it is very essential therefore to know the right stage of maturity. It has been found by experiments that, considering both the yield of the root and the toxicity, the optimum age to harvest is generally 2 years after planting, although some varieties may yield from 5 per cent and higher of rotenone at one year of age.

At harvesting time, the stems are cut and drawn to one side; they do not show any toxic value. The entire roots are then lifted or dug up, cleaned of soil and tied into bundles. The smaller roots, those which should not greatly exceed the size of a lead pencil, are separated from the big ones as they contain more rotenone.

The roots are thoroughly sun-dried from 1 to 2 weeks, depending upon the weather conditions. Where *Derris* is produced in a big scale, a special flue-heated drying chamber almost similar to that used in drying copra is employed. With this method the roots are first chopped into pieces of about 10 cen-

timeters long and then dried at a temperature of about 70° C. in 3 to 4 days. Immediately after drying, the roots should be baled, otherwise they are liable to attacks of boring insects. The bale measures approximately 1 × 0.75 × 0.70 meter and weighs about 100 kilos.

To minimize freight charges owing to the bulkiness of the product, the roots may be cut into finer pieces and packed. In other forms, *Derris* is marketed as ether extract, crude rotenone crystals, powder, etc.

The yield of air-dried roots is approximately 45 per cent of the weight of fresh ones. The moisture content of the air-dried root is about 10 per cent. Under favorable conditions the yield per hectare at 2 years of age ranges from 1,000 to 1,500 kilos of dry roots. It was reported that in Cebu from 3,000 to 5,000 kilos of fresh roots equivalent to 1,350 to 2,250 kilos of dry roots may be obtained per hectare at the age of from 2 to 2½ years.

TRADE AND MARKET

IMPORTATIONS INTO THE UNITED STATES

1931	4,508 pounds	$407
1932	38,337 pounds	6,951
1933	575,785 pounds	52,287[1]
1934	447,707 pounds	69,837[2]

[1] (All from British Malaya except 337 pounds at $40 from the Philippines.)

[2] (In the first 9 months.)

FOREIGN PROSPECTIVE BUYERS

McCormick and Co., 400 Light St., Baltimore, Maryland
William Cooper & Nephews, Cooper Bldg., 1909–25 Clinton Ave., Chicago, Ill.
McLaughlin Gormley King Co., Minneapolis, Minnesota
J. L. Hopkins, 135 Wm. St., New York City
S. B. Penick and Co., 132 Nassau St., New York City
John Powell and Co., 114 East 32nd St., New York City
E. C. England & Derris, Inc., 79 Wall Street, New York City
Peek and Velsor, 100 Gold St., New York City
Richard D. Heins, 126 Fulton Street, New York City
Frank B. Ross Company, Inc., 79 Wall Street, New York City
R. J. Prentiss & Co., 100 Gold Street, New York City
Robert F. Joyce, 125 Church Street, New York City
W. R. Grace and Company, P. O. Box 286, City Hall Station, New York City
Var-Lac-Oil Company, 116 Broad Street, New York City
Geo. Uhe, Inc., 102 Maiden Lane, New York City

DOUGHERTY MANUFACTURING CO., 1 Wilkins Avenue, Jersey City, New Jersey
HACKLEY HARRISON, LTD., 23 Harp Lane, London, E. C. 3
JOSEPH FLACK & SONS, Ltd., 64 Mark Lane, London, E. C. 3
A. TOELEY & COMPANY, Ltd., 30 Mincing Lane, London, E. C. 3
J. H. Z. STALLMAN, 29 Mincing Lane, London, E. C. 3
H. FRISCHMANN, 27 MINCING LANE, London, E. C. 3
THOMAS SWAN, 14th St., Marry Avenue, London
MITSUI BUSSAN KAISHA, 3 Kaigan-Dori, Kobe, Japan

LOCAL BUYERS

(*If there is sufficient supply*)

WARNER, BARNES & Co., INC., Perez Samaniilo Bldg., Escolta, Manila
REMIGIO RAMIREZ, Tagbilaran, Bohol
MITSUI BUSSAN KAISHA, National City Bank Bldg., Manila
GETZ BROTHERS, 5th Floor, De los Reyes Bldg., Manila
F. E. ZUELLIG, INC., 55–63 Rosario, Manila
SEBASTIAN M. GALANG, 1834 Felix Huertas, Manila
F. D. THOMPSON, 1158 Dakota, Manila
G. GONZALES, 322 Misericordia, Manila

PRICES

The current prices of *Derris* roots, f. o. b. New York City, range from 10 to 25 cents gold a pound for roots containing 1 to 5 per cent rotenone. Mr. Ramirez offers to buy from ₱0.07 to ₱0.14 for a pound of fresh *Derris* root and from ₱0.15 to ₱0.20 per pound of dry roots.

The local buyers may be consulted further for particulars with regards to conditions of purchase and price.

PROSPECTS

The United States' demand is far from being supplied; the past imports for botanical insecticides, mostly pyrethrum, amounted to about $2,500,000 a year, and more, the United States Federal Government is favoring the use of these botanical insecticides as against arsenates which are cumulative poisons.

ILLUSTRATIONS

PLATE 1.

PLATE 2.

PLATE 3.

PEANUT CULTURE

(Farmers' Circular 9)

By JUAN M. EJERCITO
Assistant Agronomist

THREE PLATES

Peanut and peanut oil constitute an important import item of the Philippines. For the last twelve years (1921–1933) our total importation amounted to ₱9,425,015 or a yearly average of ₱785,418. To minimize or curtail this importation, it is very essential to know the qualities of peanut that the market demands. At present, the increasing demand, perhaps for confectioneries is for the following classes: (1) 28 kernels to the ounce; (2) 30 kernels to the ounce; and (3) 32 kernels to the ounce. This requirement may easily be met by planting the high yielding big-kerneled varieties.

After the local demand is satisfied, the surplus production can be exported abroad. The United States is a big importer of peanut. For the last five years (1930 to 1934) her total import in nut and oil was valued at ₱4,903,660.

VARIETIES

At present there are many existing varieties of peanut cultivated in different parts of the Philippines. Many are identical to each other although they differ in their local names in different places. Others are really distinct varieties.

According to their manner of growth, the peanuts are classified into two types: (1) The bunchy type which grows erect and forms pods in clusters around the base of the plant, and (2) The runner type which has a creeping habit and forms pods along the lateral stems that touch the ground. To the former type belongs the Spanish, Cagayan No. 1, and Cagayan No. 2, Vigan Lupog, San Jose No. 3, Biit, and Tirik varieties; and to the latter, the Virginia Jumbo and Tai-tau varieties.

In the market, peanuts are again classified into big-sized nuts and small-sized nuts. The big-sized nuts are those which number 28 nuts, 30 nuts, and 32 nuts to the ounce. They are gen-

erally used for roasting, boiling, and various forms of confections. Some are also adapted for oil extraction. Virginia Jumbo, Tai-tau, Vigan Lupog, Biit, Tirik, Spanish, San Jose No. 3, Cagayan No. 1, and Cagayan No. 2 are some of the big-kerneled varieties. Some of the small-seeded varieties are the Macapono, San Mateo, Kinorales, Zambales, and Tennessee Red. For hay purposes, the Spanish variety is recommended because of its erect habit of growth and thin leaves which do not touch the ground.

SOIL AND CLIMATIC REQUIREMENTS

Peanut thrives at practically all elevations and under a wide range of soil and climatic conditions in the Philippines.

For commercial planting, however, it should be grown from sea level to not more than 500 feet elevation It prefers a warm climate and moderate rainfall throughout its period of growth. Other conditions being equal, higher yields are obtained in places where the rainfall ranges from 42 to 54 inches annually.

The best soil is a fairly deep, well-drained, and light sandy loam containing sufficient available nitrogen, phosphorus, and potash. A liberal supply of lime and humus is also highly desirable for the proper development of the pods. Hard, stiff clay soil is not suitable because the pegs bearing the would-be-pods can hardly penetrate the soil and proper development of the pods would not take place.

PROPAGATION

Peanut is generally propagated by seeds. The vegetative method of propagation—stem cutting—is impracticable on a commercial scale. Good seeds should be selected for planting. As peanut kernels are well liked by ants, it is a good practice to dip the seeds in a 2 to 3 per cent formalin solution or in mercuric chloride solution (1 to 1000 parts) for a few minutes before planting to prevent such destruction.

Preparation of the soil.—It is quite essential that the soil should be in good tilth before planting. The ground should be tilled at least 30 centimeters deep at the first plowing. Two to three plowings, each followed by a harrowing made at 10 to 15 days interval, are sufficient to put the soil in good tilth. In the course of these operations, all stubles, weeds, and obstructions of all kinds should be removed.

Planting.—It requires about 30 kilograms of seeds of the Spanish variety and other similar sized varieties to plant a hec-

tare. With the creeping varieties, like the Virginia Jumbo and Tai-tau, about 26 kilograms are sufficient because they are planted farther apart than those of the bunchy type.

The bunchy type is generally planted 65 centimeters between rows and 35 centimeters between hills on the row. The creeping type is usually spaced 50 to 80 centimeters. Three seeds are planted to every hill. They are covered with fine soil at a depth of 2 to 3 inches. During the dry season when the planting is delayed and there is no sufficient moisture in the soil, it is advisable to soak the seeds in water overnight before planting to hasten germination. Only well-seasoned seeds from the preceding crop should be planted.

Peanut can easily be raised twice a year in places with distinct wet and dry seasons or in places with intermediate conditions between the said two seasons. Plantings made at the start of the rainy season (usually in May or early part of June) are harvested in September, and those made at the beginning of the dry season (usually in November or in the early part of December), in January or February. This holds true with the bunchy type. Of course, it takes longer for the runner varieties.

Cultivation.—Start to cultivate when the weather is fair and as soon as the plants have four or five leaves. Pass the plow once or twice between the rows making it a point to cover the base of the plants while at the same time killing the weeds. Cultivation may be done as often as necessary until the plants have sufficiently covered the greater portion of the ground. If the soil gets compact after the heavy rains, the surface should be stirred with a hoe as soon as it is reasonably dry. Dust mulch will be formed to check too much evaporation of the soil moisture.

Fertilization.—The use of fertilizers with peanut is not a common practice in this country due to the fact that most of the land planted to this crop are generally of the rich, alluvial or sandy loam type. Moreover, the same land is not continuously cultivated to peanut for a number of years. Also, peanut, being a leguminous plant, is more of a renovator than an exhaustive crop. It only becomes an exhaustive crop when the root-bearing nodules are removed from the soil. In this case the use of fertilizers becomes necessary. Some of the fertilizers which have been found to increase the production of peanut are wood ash, stable manure and, for thin sandy soils, a complete fertilizer mixture analyzing 2 per cent nitrogen, 8 per cent phospho-

rus, and 4 per cent potash, applied at the rate of 300 to 500 kilos per hectare. Lime improves the quality of the peanut. The pods are usually better filled and the shells are whiter.

The yield may also be increased by soil inoculation. This was the result of an experiment conducted by the Institute for Agricultural Teachers, at Langersari, Bandoeng, Java, in which an untreated plot produced only 448 kilos while the plot inoculated with 8 hundred weights of bacteria-bearing soil per acre or about 894 kilos per hectare, produced about 558 kilos per hectare or an increase of 110 kilos over the untreated plot.

SPECIAL CULTURAL PRACTICES

In the United States, after the final cultivation a light roller is run over the plants to flatten the stems upon the ground. This operation enables the pegs bearing the would-be-pods to reach the soil and cause the maximum number of pods to mature at almost the same time. This practice is done only with the runner varieties which are not injured by the roller. With the bunchy type, it is neither necessary nor advisable.

HARVESTING

Maturity is indicated by a light yellowing of the foliage (not due to disease or pest), and the darkening of the veins inside the shell. The usual maturing period is from 105 to 125 days for most of the bunchy type varieties and from 165 to 185 days for most of the runner varieties.

Harvest when the soil is reasonably dry. One objection against the coincidence of maturity with the rainy days is the difficulty of harvesting when the soil is too wet. Pending better weather, the pods get over-mature and may rot or germinate. The drying of the newly harvested pods is difficult.

CURING

Curing is not generally practiced in the Philippines. The usual practice is to pick the pods immediately after the harvest, clean them of soil, and dry them well in the sun. This results in the production of many shriveled kernels. Through proper curing, as described hereunder, this defect will be overcome.

After the plants are dug up, they are shaken to remove as much as possible the adhering soil particles on the pods, and spread on the ground for exposure to the sun to wilt the vines slightly. Then they are placed in small stacks around poles to

which two or more cross pieces have been nailed or tied at right angles to each other, about 30 centimeters from the ground.

The poles are about 2 meters long and $2\frac{1}{2}$ centimeters in diameter at the base and sharpened at both ends. The cross pieces are about 40 centimeters long. Bamboo or wood may be used for this purpose.

The vines are stacked around the poles with the pods adjacent to the poles. The completed stack should be about $1\frac{1}{2}$ meters high. The top is capped with some weeds or straw to protect the stacked peanuts from the rain. Normal curing lasts from 4 to 6 weeks.

PICKING AND SHELLING

Pick the pods during bright and hot weather when the vines are brittle and picking easier. During cool weather the vines are rather tough and picking is difficult. Separate the marketable pods from the unmarketable ones while picking. Properly picked pods should be free from stems, dried leaves, and other foreign materials.

The native and usual way of shelling is to press the pods between the fingers, taking care of course, not to press so hard as to split the kernels. Plenty of split kernels lower the quality of the product in the market. The hand method of shelling is quite slow, laborious, and expensive when the crop is handled on a commercial scale. The work may be facilitated and the expenses minimized by the use of a shelling machine.

YIELD

Like any other crop, the yield of peanut varies with the variety, season, type of soil, culture, diseases, and pests, etc. At the Lamao Horticultural Station of the Bureau of Plant Industry, it was found out from the four years' test that the three highest yielding varieties were San Jose No. 3, 12.69 cavans of kernel; Spanish, 12.55 cavans; and Tennessee Red, 11.99 cavans. At the College of Agriculture, Los Baños, Laguna, it was reported that Valencia gave an average production per hectare of 26.4 cavans pod or about 16.3 cavans kernel; Spanish Red, 19.4 cavans pod or 14.74 cavans kernels; Vigan Lupog, 25 cavans pod or 18.25 cavans kernel; and Kinorales, 23.1 cavans pod or 17.78 cavans kernel. In the entire Philippine Islands, the average yield in 1935 was 547 kilos per hectare or about 12 cavans of shelled nuts.

One of the principal ways of curtailing the importation of peanuts in the Philippines is to produce by selection or hybridization varieties which are high yielding, big-seeded, early maturing, and disease resistant. The Bureau of Plant Industry is now working along these lines.

The final profit depends very much on the price of peanut. Assuming that the price is ₱7 a cavan, which is very conservative, the value of the harvest per hectare would be ₱75. Upon the ability of the farmer to reduce the cost of production depends his profit to no small extent.

COST OF PRODUCTION

The cost of raising a hectare of peanut varies, depending upon many factors, such as: season, soil type, variety, culture, labor conditions existing in the locality, etc. From land preparation to preparation of the crops for the market, the Bureau of Plant Industry has found that the total expenses amount to ₱87.41 per hectare. The College of Agriculture, Los Baños, Laguna, has reported that it costs ₱86.57 in the wet season and ₱77.22 in the dry season to produce a hectare of peanut.[1] The above costs were based on ₱1.00 per man-day and ₱0.80 per animal-day. In localities where daily labor is from ₱0.40 to ₱0.60, the cost of production would be greatly minimized.

[1] College of Agriculture Bi-weekly Bulletin, Aug. 15, 1933.

ILLUSTRATIONS

PLATE I.

PLATE 2.

PLATE 3.

THE GENERAL PRACTICE OF LOWLAND RICE FARMING IN THE PHILIPPINES

(Farmers' Circular 39)

By Basilio R. Bautista

Assistant Agronomist

SEVEN PLATES

Rice is the most important crop of the Philippines. It is the main article of food of the people.

The average production of rough rice in the Philippines, according to statistics, was 26.9 cavans per hectare in 1933–34. In India, under the irrigated areas the average production per hectare is 34 cavans; in Java, 37 cavans; in U. S. A., 44 cavans; in Japan, 76 cavans; in Italy, 98.5 cavans; and in Spain, 144 cavans. Obviously, there is much room for improvement in our rice farming to increase the yield per unit area. This paper deals with conditions of rice farming in rice districts in the Philippines with some suggestions offered for the improvement thereof.

GROUND PREPARATION

Seedbed.—There are various types of seedbeds which are prepared under different methods as follows:

Type 1.—In Northern Luzon, chiefly in the Ilocos Provinces including Cagayan, Isabela, and the Mountain Province, the general practice is to prepare dry seedbed located on a high place with fertile soil, instead of locating them in the lowland as is done in Central Luzon.

This type is not, however, uncommon in northern parts of Nueva Ecija and Tarlac where the Ilocanos are working the lands. The method of preparing the seedbed is similar to that of the upland rice, consisting of from two to three plowings each followed by harrowing. At the first available hard rain in May or June the seeds are hand-drilled in rows to amount 25 gantas per 200 to 250 square meters to plant a hectare. On account of the thick seedage the seedlings produced are slender and apt

to form nodes at the age of over 35 days from date of sowing. On account of the uncertainty of water supply, which depends entirely on rainfall, it is oftentimes necessary to wait as much as six to eight weeks, before the rice could be transplanted. Then the seedlings are over the planting age and will give low grain yields. This method may be applied on irrigated places where the area of lowland rice field is limited. To produce stocky seedlings the area of the seedbed should be increased to 500 square meters to allow more space for their proper development.

Type 2.—The method employed in some of the Visayan Islands is the same as the Ilocano method, Type 1, except that the seeds are broadcasted at the rate of 25 gantas per 150 to 200 square meters. The defects of the seedlings produced are the same as in Type 1 of seedbed, which may be improved by increasing the area to 400 square meters, and covering the seeds after sowing by light plowing and harrowing. The seedlings in both cases may be planted in five to six weeks old.

Type 3.—In Central Luzon, the ground is generally plowed once, and harrowed twice, and in 3 to 5 days the seeds are sown. The farmers usually do not take into account the area of the seedbed necessary for sowing a given amount of seed, and this results in overseeding and consequently, weak seedlings are produced. Under normal conditions, a well prepared seedbed should have at least 15 to 16 days preparation. The first harrowing should be done 3 to 4 days after breaking or first plowing. This consists of breaking the clods and incorporating the organic matter into the mud; 7 to 8 days after first harrowing, crosswise and lengthwise harrowings follow to destroy the weeds and level the ground. Three days afterward, the third harrowing or puddling preparatory to sowing is made. Before the seeds are sown a flat board of sufficient weight is passed over the seedbed to smoothen the surface and make it convex longitudinally so as to provide a run-off for surplus water. Two or three hours later, the mud thus settled, the seeds can be sown at the rate of 25 gantas for every 333 to 400 square meters, enough to plant a hectare. In most cases the farmers do not close the gate of the seedbed after sowing which results, in the event of hard rain, in the carrying away the seeds by water. Seeds sown immediately after preparing the seed-bed would

sink deep into the mud, in which condition they are prevented to grow, or otherwise the resulting seedlings would be hard to pull up when the time for transplanting comes. After twelve hours from sowing, the surplus water should be removed by opening the gates so as to facilitate the growth of the incipient seedlings and at no time the seed bed should have standing water, for this will render the seedlings hard to pull up preparatory to transplanting. It is necessary therefore, for the seed, bed to be located in a place that can be irrigated and drained at will. Preferably rich soil should be selected. The seeds before sowing should be soaked overnight, then drained for one and a half day under shade and kept moist to hasten germination. As a general rule the seedlings of different varieties can be transplanted at the age of 5 to 6 weeks; beyond this age the seedlings will have produced nodes, one of the factors that cause low production of grains.

LAYING OUT AND PREPARATION OF THE FIELD

Experience shows that the ability of a given paddy or paddies to retain water in much longer time depends upon the lay out of the dikes or levees. Paddies having higher grades are subject to lose water in shorter time due to natural seapage. On hill sides, the size of the paddies is determined by a fall of 20 and not more than 30 to 40 centimeters. The dikes, of course, should be thick enough to retain water. Loose soil should have bigger dikes than clay soils.

Gravelly and sandy soils after harrowing, settle immediately through the action of running water. To avoid replowing due to settling, running water should be cut off by closing the gates

The use of the proper implements gives proper impetus in the rice farming. The employment of bamboo harrow and spike-toothed board is a draw back in good farming as these implements are inefficient, both in leveling the soil and incorporating the organic matter into it. The general use of these implements in Northern Luzon and in the Visayan Islands accounts for the thick growth of weeds in the rice fields, in spite of irrigation and other good factors present. It may be noted also that unevenness of the surface of the paddies, especially under the irri-

gated areas, is the cause of uneven maturity of the crop. The right implement to be used in harrowing is the native steel harrow (suyod) which is generally employed in rice farming in Central Luzon (*see* Plate 1). The trampling or yatac method by carabaos of soil preparation preparatory to transplanting as is done in the Visayan Islands, is bad practice for the simple reason that transplanting follows immediately and not sufficient time is allowed for the decomposition of the organic matter. Under exceptional condition, such as deep wallow, where plowing and harrowing are impossible, this method may be resorted to.

The farmers in general prepare the land in a crude way, that is, in addition to one plowing, the field is harrowed one or two times preparatory to transplanting. This method does not allow the proper decomposition of organic matter. It is the general conception among rice planters that one plowing and two harrowings are enough to produce a good stand of rice crop. This may be true under exceptionally good soils but under the average soil fertility in Central Luzon and elsewhere, one plowing with three or four thorough harrowings before transplanting will be the most appropriate method of ground preparation.

In good rice farming, it is very necessary that the soil in the paddy be well "mucked," so to speak, 18 to 21 days. It is common but erroneous practice, that while harrowing, the water in the paddies are kept running or flowing with the main object of removing weed seeds present. This is detrimental to the preservation of soil fertility, and should be done only after the soil has settled down. The right procedure is to provide only sufficient amount of water to facilitate harrowing, and to close the gates while harrowing in order to prevent sheet erosion. The ground should at no time be allowed to bake. It is a common observation that no special attention is given to the proper construction or repairs of dikes. Good dikes should be at least 45 to 50 centimeters thick and 50 centimeters high on clay soils, and much thicker on loose soils to have a better control of the irrigation water.

Type 4.—The "dapog" seedbed method is one that would save indigent farmers. It has several advantages, namely:

(*a*) The seedlings could be planted in 9–12 days from date of soaking. Rain-fed areas where the supply of water for gen-

eral preparation is uncertain, should practice this type of seedbed for the reason that the general field is already prepared in time when there is sufficient water to start the seedbed.

(*b*) In case the planting season has far advanced due to lack of water supply or, as the case may be, the rice after planting has been destroyed by floods, or damaged by pests, replanting of the field may be desirable, and seedlings should be raised by the "dapog" method.

(*c*) The seedlings produce earlier crops, saving from 15 to 20 days in the usual maturing period.

In preparing this type of seedbed, the ground should be plowed, harrowed, and well puddled similar to that of type of seedbed No. 3. The ground thus prepared should be laid on with one layer of whole banana leaves. Torn leaves should be patched up with a piece of the leaf to prevent the roots of the seedlings to penetrate into the ground, lest the tender seedlings be spoiled in pulling up preparatory to transplanting. The leaves thus laid with sides overlapping each other to permit no space between them with prominent midribs underneath, are pressed lightly downward so as to allow the accumulation of mud to a depth that would permit the growth of germinating seeds. The seeds previously soaked and drained for 36 hours can then be sown. The "dapog" seedbed requires an area of 30 to 45 square meters in the form of small convenient-sized lots to hold 25 to 30 gantas of seeds in all, which are sufficient to plant a hectare allowing for the seeds that died out due to overcrowding. In the absence of rain or irrigation water, the seedbed should be watered, and no standing water be allowed to prevent scalding due to sun heat. In 9 to 12 days, the seedlings should be transplanted, otherwise the seedlings will have formed nodes or grow spindling. The seedlings under this type of seedbed have the roots interlaced in mat-formation, which should be divided into convenient sizes to facilitate handling by the planters. Planting is generally much thicker than in the case of other seedlings, and a hill may contain from 6 to 8 seedlings.

"Dapog" seedbed may be constructed under the shades of banana trees, coconuts, etc. The media that could be used, to be placed on top of the banana leaves, are either rice-hull or rice-chaff of the same variety to be planted, fine-chopped rice-straw or sand. If other medium than sand is used, it should

have a slight dressing of either sand or fine soil, so as to fill the inter spaces. The seedbed should be sprinkled with water before sowing the seeds and watered thereafter, morning and afternoon, depending upon the weather condition. After sowing, the seeds should be covered with a thin layer of fine sand or soil to prevent their rapid drying. These matters should not be overlooked.

CARE OF THE CROP

After transplanting, the rice field should be taken care of. The gates should be kept closed; the field should not be exposed to surface erosion, and weeds be removed as soon as developed. (Plate 2.) It should be known that weeds crowd out rice plants and inhabit tillering. The most approved method in the care of the crop after planting is to close the gates to about 10 centimeters high after transplanting to avoid any possible loss of soil fertility. From 7 to 10 days after, irrigation water can be applied to a depth of 8 to 10 centimeters, gradually increasing it to 18 to 20 centimeters as the plants increase in height, and depth of submergence maintained during the growing period to prevent the growth of weeds at the time of tillering. (*See* Plate 3.) Productive tillers are usually produced within three months after transplanting so that after that period the submergence may be lowered gradually to 10 down to 8 centimeters deep. Occasional draining should be practiced to prevent water stagnation and to allow aëration, but irrigation water should be applied before the soil begins to crack, otherwise the plant growth will be checked. Weeding, if necessary, should be done, especially during the growing period of rice by pulling up the rootstocks instead of the general practice in some of the southern islands of merely topping off the weeds with the use of bolo or scythe, thus leaving the rootstocks to grow again and feed on the soil fertility, and depriving the rice plants of some food and sunlight. In case of ranky growth that would cause lodging the irrigation water may be withheld until all the leaves have shown stiffness, for the leaves of lodging rice are dark green, soft, and bending downward.

The care of the transplanted "dapog" seedling is very important, and that if not properly attended to, it is liable to lose part or the whole of the rice crop. All the gates, after transplating should be closed to prevent washing out and the paddies kept in saturation only from three to four weeks after transplanting

to allow the young plants to develop. Draining should be made to prevent the drowning and scalding of the tender plants during hot days. When the plants have attained the height of about 20 to 25 centimeters, the same care as the ordinary rice crop can be given. Irrigation water should be removed at dough stage to hasten maturity, and harden the soil before harvest time.

VARIETY SELECTION

It has been the practice from time immemorial that the seeds for planting are obtained from the farm's granary just before sowing time. The seeds thus obtained consist of different mechanical mixtures and broken grains due to the use of modern threshing machines. Mixed seeds cause non-uniformity of maturity and type of grains, hence affect adversely both the quantity of production, and the quality of the product. The seeds should therefore be secured at maturity just before harvest time to insure better germination, purity of the seeds, yields, and quality. As a general rule, landlords determine the varieties to plant and in most cases, the use of the right variety is overlooked.

In sugar cane lands or the like converted into rice fields, where the nature of the soil is porous and where water does not stay long, and in places that are hard to irrigate, early varieties, such as Apostol, Guinangang Str. 1, and Inachupal I are much preferred. Other early varieties may do well, but none so far have outyielded the varieties just mentioned. In places that are easy to irrigate, retentive of water, and easy to drain, the medium late varieties are best adapted, such as Macan Tago, Macan Santa Rosa, Macan Aga, Macan China, Manticanon, Mancasar Str. 3, Kho Bai Sri, and several others. In places that are fertile, easy to irrigate, retentive of water, and easy to drain, Khao Bai Sri, Manticanon, Macan Lamio, Inadhica, Elon-elon and Ramai are best adapted. In places that are water logged, where other varieties do not do well on account of their weak straw, Elon-elon and Ramai will do well.

It is of interest to note also that in some places strong northeasterly winds occur from about the middle of November up to March. In regions like these, and where soil conditions are normal, usually the pollination of the late varieties is much affected, hence more chaffy than full grains are produced. Under this condition, both the early and the medium late groups will do well.

The following is the table showing the average yield of commercial rice varieties:

Variety names	Number of days to maturity	Yield per hectare	Special qualities
Guinangang Str. 1	140	61	Can be grown also as palagad and it matures in 157 days.
Apostol (called in Bulacan as Señora II)	144	66	Dual purpose, may be used as upland and lowland rice, superior grade and good eating quality.
Inachupal	169	54	Considered as ordinary rice.
Khao Bai Sri	183	59	Much in demand in the market for its good milling and eating quality.
Macan Tago	180	51.5	Considered as ordinary rice.
Mancasar (known in Bulacan as M. San Isidro)	178	62	Do.
Macan Santa Rosa	180	68	Do.
Manticanon	184	68	Do.
Macan Lamio	184	60.4	Considered as ordinary rice with good eating quality.
Elon-elon	194	65	The variety that is exported to the U. S. much in demand on account of its superior milling and good eating qualities.
Inadhica	194	61	Weak straw, soft rice with good eating quality.
Bangbang	195	67	Fair milling and eating quality.
Ramai	196	76	Good milling quality and poor eating quality.

SEED SELECTION

Under normal condition, like begets like so that seeds taken from the granary consisting of different mechanical mixtures in addition to poor yield characters, because of the existing varied population, have no end in the improvement of the variety both in yield and quality and also adaptability to a certain extent. A standing crop of rice may be good at a glance, but upon close observation it may be found that the heading or maturity is not uniform, which is one of the factors responsible for low production.

There are various methods of improving rice varieties, but one which is most practicable, and which is within the means of rice farmers, will be discussed in this paper as follows:

Mass selection.—At maturity, before harvesting, select representative lots where selection of the seeds will be conducted. Select only the best plants standing erect and having the most number of bearing culms with uniform height, uniform maturity, with full grains free from sterility, and diseases. Avoid selecting plants that are favored by outside influences such as drop-

pings of animals and flow of natural fertility from the surroundings, also border plants having the advantage of light are to be avoided. About a ganta of the seeds will be sufficient, the more the better, to start with. The seeds thus selected should be dried, cleaned, and kept until the planting season. These seeds should be sown in a special seedbed, and the resulting seedlings planted in separate paddies using only one seedling per hill with spacing of about 20 x 20 to 25 x 25 centimeters depending upon the fertility of the soil. Medium rich soil is much preferred as test plot. Condition being normal, and only one seedling planted per hill, good plants as described previously manifest the desirable characters that are essential in the improvement of a given variety. From this crop, the selection of seeds for improvement should be made for continuous selection until the fourth generation is reached. Although the product of this method of seed selection consists of mixed strains, still they are superior to the original stocks. The good plants selected from the fourth generation should be used for further selection until the maximum production is reached. The remnants from the fourth generation up to succeeding generations can be propagated for general plantings, using the seeds of the ensuing generations for the following planting season. To be more explicit, a farmer should provide himself with a test plot of convenient size where to do continuous seed selection work and a propagation plot to propagate the selected seeds enough to give him material to plant his whole rice field from year to year until the desired results are obtained.

After the rice harvest the field is bare-fallowed, so that there is a constant drain of soil fertility, from year to year, which is never replaced and which explains why most of our rice soils nowadays are worn out. According to Bulletin No. 37, Rice in the Philippines, by Jose S. Camus, p. 40, that an average production of 40 cavans or 1,744 kilos of rough rice (palay) to the hectare, the following amounts of soil fertility are removed:

Nitrogen	20.64 kilos
Phosphoric acid	10.32 kilos
Potash	4.54 kilos

If an equal amount of straw is removed, the following quantities of plant food elements are lost:

Nitrogen	11.00 kilos
Phosphoric acid	2.44 kilos
Potash	28.03 kilos

Of course, straw is left in the soil and part of it is eaten by animals and the worst disposal of it which should be condemned is the wholesale burning after rice harvest, for what is being recovered only is the potash which is present generally in sufficient quantity, whereas the nitrogen and the phosphoric acid are lost completely. Burning rice straw may be done only within certain limitations. It is permissible where the field has been seriously infested with insect pests or else infected by a disease.

The loss of nitrogen and phosphoric acid can be replaced by the use of green manure which is done by broadcasting legumes such as mongo, tapilan, and others at the rate of 15 to 25 gantas per hectare; and plowing the crop under while in full bloom or just before the pods are formed.

FLOATING RICE

There are three varieties of floating rice that are under trial by the Bureau of Plant Industry. These varieties are the Kra-Suey, Seniñora I, and Seniñora II. The tests made show that Kra-Suey is promising. The variety has shown adaptability in low places that are subject to deep submergence. Areas that are affected by strong flood current are not suitable to this variety for the crop will be carried away by the stream. It thrives best on where the rise of water is gradual and can stand deep water as long as the youngest leaves are above the water. Series of tests had been made in Candaba, Pampanga, and the average production per hectare so far found was 25 cavans to the hectare, and in swampy places in Pangasinan an average of 20 cavans was secured when previously little or no crop at all from those places were realized. The plants grew as high as 3 meters or more.

The planting is similar to that of an ordinary upland rice after the land has been prepared in the usual way. The seeds are broadcasted at the rate of 25 to 30 gantas per hectare, followed by light plowing with harrowing thereafter to cover the seeds. Planting is usually done in the latter part of April or in May when there is sufficient moisture in the soil to keep them growing until flood time.

PALAGAD RICE

The planting of palagad rice generally begins from November to February. The planting is done either by direct broadcasting or transplanting method. For best results, transplanting is the

best method that should be followed. The seedlings may be produced in accordance with seedbed type No. 3 or type No. 4 described previously in this paper, but for best results as obtained in the Province of Laguna, where extensive palagad rice planting is made, seedlings produced by "dapog" seed bed, type No. 4, should be used.

In the following table is shown the varieties of rice that are recommended for palagad purposes:

Variety name	Number of days to maturity	Yield per hectare (cavans)	Quality of rice
Guinangang	152	50.0	Ordinary.
Sipot known as Binuhangin in Siniloan, Laguna	144	45.0	Ordinary.
Kinawayan	144	45.0	Do.
Sinadyaya	135	34.0	Do.
Dinagat	137	32.0	Do.
Inintiw	135	32.0	Do.
Mangasa (Tanza)	137	32.0	Do.
Pinursigue	135	30.0	Do.
Balibod	137	30.0	Do.
Baranay	139	29.0	Do.
Binicol	135	25.0	Aromatic and soft.

The Binicol variety does best by direct broadcasting at the rate of 30 gantas to the hectare, and requires shallow submergence or saturation to maturity.

SOIL FERTILIZATION

Lands with average production of 35 to 40 cavans per hectare need to be fertilized at the rate of 150 to 200 kilos of ammonium sulphate per hectare. Other chemical fertilizers supplying from 30 to 40 kilos of nitrogen per hectare may be used. Complete fertilizer supplying 30 kilos of nitrogen, 30 kilos of phosphoric acid, and 40 kilos of potash may be good also. Sandy soil does not pay to be fertilized on account of the porous nature of the soil, however, application may be made, provided, that the place is provided with natural hard pan that will prevent the loss of the fertilizer due to sinking. Poor seedlings may be fertilized as top dressing at the rate of 60 to 80 kilos per hectare with ammonium sulphate; seedlings that are destroyed by cut worms may be treated also with the same amount of the fertilizer in order to bring them back to normal condition, fit for transplanting purposes. The application of the fertilizer in all cases should be made when the paddies are at the saturation point

only, that is, all surplus water be drained completely, and the gates closed after the application to prevent the loss due to leaching. After a week time the gates should be opened to remove the stagnant water. In the case of the planted field, the removal of the stagnant water due to the closing of the gates after the application of the fertilizer is very important also. The crop can be kept irrigated, from time to time as required.

PESTS AND DISEASES

The most common pest attacking the rice seedlings in the seedbed is the army worms, *Spodoptera mauritia;* it can be prevented by light trapping the adult insects and collecting the masses of eggs deposited on the leaf-blades before they hatch into larvæ. While in the larval stage, flooding whenever irrigation water is available, is the most effective control. In order that flooding will be effective, the dikes should be repaired to prevent possible leaking, and should provide also a sort of a raft laid on top of the water where the larvæ will crawl for safety which could be rolled off to collect the pest. The operation should be repeated until all the worms are collected. The use of calcium arsenate and rice bran poison is also effective. The calcium arsenate is applied as dust with a fine sinamay bag or a rice gunny sack early in the morning or in the evening while the leaves are still moist. The rice bran poison is to be applied while the ground is dry. The bait is scattered on the infested fields. This will induce the larvæ to stop and eat the poison baits. Another serious pest attacking the rice plants is the stem borers. The attack is very severe in the latter part of July and in August, and part of September.

Symptoms.—General yellowing of the leaves with the youngest leaf drying. The young larvæ, upon examining the affected rice plants, may be found inside the stem eating the tender parts.

Control measure.—Plants attacked with this pest generally do not recover, so that it is necessary to pull up the plants with the root-stocks and burn them or bury deep into the mud to destroy the larvæ or pupæ in order to cut off the cycle of the pest. Light trapping with the coöperation of the neighboring planters will also be a good control measure.

Rice bug, *Leptocurisa acuta* is a serious rice pest that causes severe losses on grain yield, especially on early varieties of rice planted in a limited scale.

Symptoms.—The presence of insects sucking the rice grains in milk stage; panicles of rice standing erect with light straw color as though matured with empty grains.

Control measures.—Tall grasses harboring the pest should be cut down. A month before heading of the crop, bait such as putrifying meat should be hung on poles of convenient height along the borders and interior dikes where the pest could feed on. At sun-rise and before sun-set the insects are found on the host, and that by passing a lighted torch under the bait will destroy the pest. Other measure, such as planting rice in a bigger scale, will minimize the destruction made by the insects as well as birds.

STEM ROT DISEASE OF RICE

The stem rot, *Sclerotium oryzea* is a serious disease found affecting the rice plant which is found common on places with stagnant water. Rice plants affected with the disease never recover. Varieties of rice with weak stems or straw are very susceptible.

Symptoms.—The plants look healthy, but bending and reclining downward. When the plants are pulled up, they separate easily from the rootstocks and emit putrifying odor, due to the general rottening of the stems. The disease could be transmitted by insects, animals, and water.

Control measures.—Prevent animals and insects from entering the infected fields. Avoid the use of irrigation water coming from the infested field. Pull and burn all diseased plants when the infection is first starting. Burn the rice straw after rice harvest if the field is badly infected. The use of lime in the amount of 600 to 700 kilos per hectare is beneficial, besides correcting the soil acidity also. Plant resistant variety, such as Raminad Str. 3. Varieties, such as Elon-elon and Ramai may be used, but none so far have surpassed the resistance of Raminad Str. 3 in this respect.

SUMMARY AND RECOMMENDATIONS

1. Soils where gravel and sand predominate, usually return to compact form after harrowing through the action of running water, so that it is necessary to cut the flow of water to avoid replowing.

2. Efficient implements, such as native plows and native steel harrow (suyod) be used instead of the bamboo harrow or spike-tooth board, for better ground preparation.

3. Size of the seedbed be 333 to 400 square meters per cavan of seed for a hectare of field under lowland condition, seedbed type No. 3; 500 square meters when sown in drill and 400 square meters when broadcasted under upland condition, seedbed types Nos. 1 and 2 respectively, and 30 to 45 square meters under "dapog" seedbed, type No. 4. Mucking of the soil preparatory to planting should last 18 to 21 days from the first to the third or fourth harrowings in order to get a better stand of the crop.

5. On poor soils the spacing of the hills should be 18 x 18 centimeters to 20 x 20 centimeters. Under this kind of soil, the rice plants seldom, if at all, prduce stools. On medium rich soils, the spacing between hills is 20 x 20 to 25 x 25 centimeters. Rice plants under this kind of soil produce a fair number of tillers so that there will be crowding if not properly spaced which may result in lodging. On soils that are rich, the spacing should be 25 x 25 centimeters or more depending upon the location and the variety to be planted.

6. For varieties with poor tillering characteristics, 5 to 6 seedlings should be planted per hill, and those with profuse stooling character, 3 to 4 seedlings per hill.

7. Irrigate the field 7 to 10 days after transplanting with a submergence depth of 8 to 10 centimeters; increasing this depth to 18 to 20 centimeters and maintaining this depth for three months, thereafter lowering the depth to 10 centimeters down to 8 centimeters to prevent weed growths. At dough stage, water should be completely drained off to hasten maturity.

8. Place the gates of succeeding paddies diagonally in order to prevent surface erosion.

9. Practice weeding by hand pulling to remove the rootstocks instead of merely topping the weeds by bolo or scythe.

10. Plant the right variety and practice seed selection.

ILLUSTRATIONS

PLATE 1

Preparing the field with the use of Central Luzon harrow.

PLATE 2

Field newly transplanted.

PLATE 3

Section of a field overgrown with weeds that make tillering difficult.

PLATE 4

Rice plant showing development of stools and roots.

PLATE 5

An irrigation ditch where water flows to irrigate different sections of the field.

PLATE 6

Weeds crowding out rice plants and diminishing the crop.

PLATE 7

Harvesting rice in Central Luzon.

PLATE 1.

PLATE 2.

PLATE 3

PLATE 4.

PLATE 5.

PLATE 6.

PLATE 7.

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